

2016

A Geology Field Trip

John J. Renton

Thomas Repine

Follow this and additional works at: https://researchrepository.wvu.edu/earthscience_readings

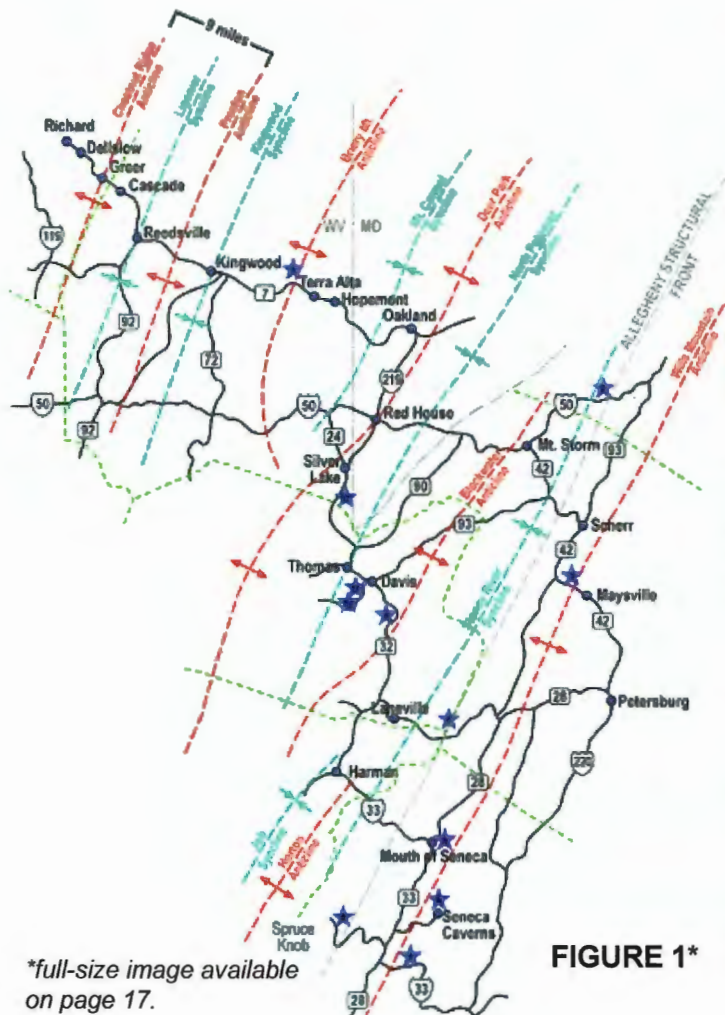


Part of the [Geology Commons](#)

A GEOLOGY FIELD TRIP

by

Dr. John J. Renton
Dept. of Geology and Geography
West Virginia University



*full-size image available
on page 17.

FIGURE 1*

Introduction to Field Trip

I had several objectives in mind when I prepared this field trip. I want to develop in you an interest, an understanding, and an appreciation of geology of the region. I want to show you differences between three of the basic physiographic provinces within Appalachia, the Low Plateau, the High Plateau, and the Appalachian Mountain Section of the Valley and Ridge Province. I also want to show you the role that the kinds and structures of the underlying rocks plays in the formation of the topography of a region in order to have you better understand why the appearance of the land changes as you travel about the country. During the trip, you will also see excellent examples of the process of weathering as well as the erosive power of streams. The trip will visit several tourist areas and, in addition to their scenic beauty, you will learn that they represent excellent examples of important geologic features.

ROAD LOG

Introduction: As you begin the trip, there are two figures you will want to keep handy; Figure 1*, which is the road map showing the path of the trip and Figure 2 which is the stratigraphic column that lists all of the rock formations you will encounter on the trip and their

FIGURE 2

Rock Units Observed During Trip	Period	Middle	Pottsville Group	Kanawha Fm
		Lower		New River Fm Pacheco Fm
	Devonian	Upper	Mauch Chunk Group	
		Lower	Greenbrier Group	
	Carboniferous	Upper	McCready Fm	
		Lower	Price Fm (Pocahontas)	
	Permian	Upper	Berea	Hampshire Group
		Middle	Huron	Foreknobs (Chemung)
	Triassic	Middle	Millboro	Brallier Fm Hamrell Fm Manhantango Fm Marcellus Shale
		Lower	Onondaga Limestone	Hunterville Chert Needmore Shale
Rock Units Observed During Trip	Jurassic	Upper	Oriskany Sandstone	
		Lower	Helderberg Group	
	Cretaceous	Upper	Tenloway Limestone	
		Lower	Salina	Wills Creek Fm Newburg Fm Williamsport Fm Bloomburg Fm
	Tertiary	Upper	Lockport	McKenzie Fm
		Lower	Keeler Sandstone	
	Quaternary	Upper	Rose Hill Fm	
		Lower	Tuscarora Sandstone	
	Pleistocene	Upper	Junata Fm	Conoco Sandstone
		Lower	Reedsville Fm	Marshallburg Fm
Rock Units Observed During Trip	Holocene	Upper	Trenton Group	
		Lower	Black River Limestone	

FIGURE 3

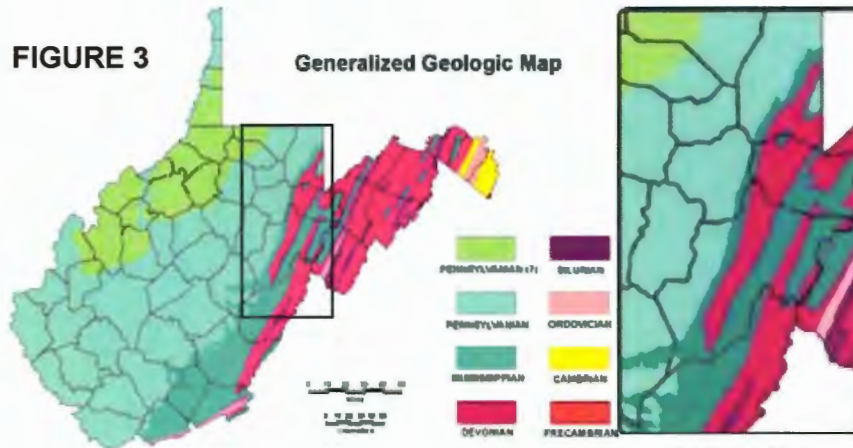


FIGURE 4

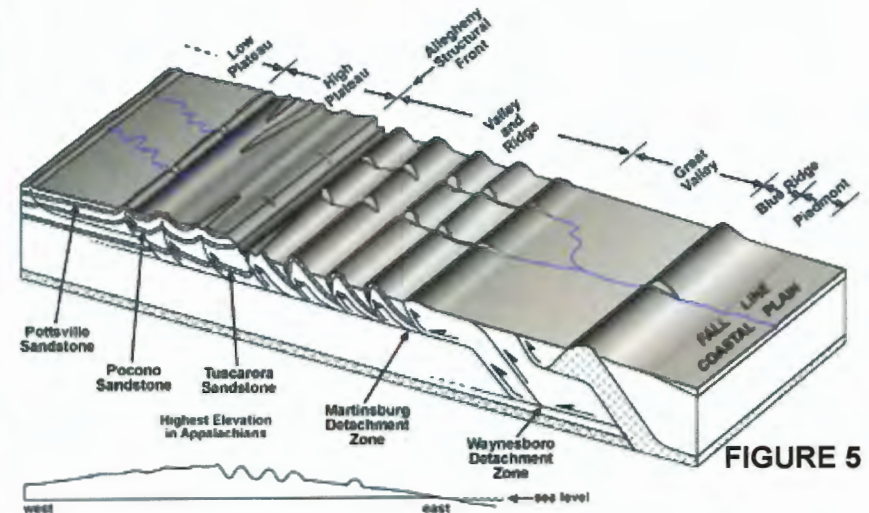


FIGURE 5

relative ages. I have also provided the Geologic Map of West Virginia (Figure 3) and an enlargement of the portion of the geologic map that we will be traversing in our trip (Figure 4). Other figures are provided which are designed to provide you with more detailed information about the geology you will be seeing at individual stops.

Morgantown, WV

At Morgantown, you are near the eastern boundary of the Appalachian Low Plateau (Figure 5). All of the rocks you observe in road cuts west of Morgantown are Pennsylvanian in age and consist primarily of inter-layered sandstones, shales, and coals with a limited number of limestones. The Low Plateau is underlain by very low amplitude, symmetrical folds. In fact the amplitudes of the folds are so low that the beds of the exposed rocks appear horizontal. In contrast, while the structures within the High Plateau, while still symmetrical, have amplitudes that are high enough to appear as distinct northeast-southwest trending ridges such as Chestnut Ridge. With the summit approximately 1,000 feet (300 m) higher than Morgantown, Chestnut Ridge Anticline forms the eastern skyline as you approach Morgantown from the west.

Note: a majority of the illustrations are provided to illustrate a geologic concept. They have no implied scale unless otherwise noted.

Morgantown, WV, to Dellslow, WV

Proceed to Sabraton and continue east on WV Rt 7. The portion of the trip from Morgantown to Kingwood can be followed on the cross section and map shown in Figure 6*. All of the rocks throughout the

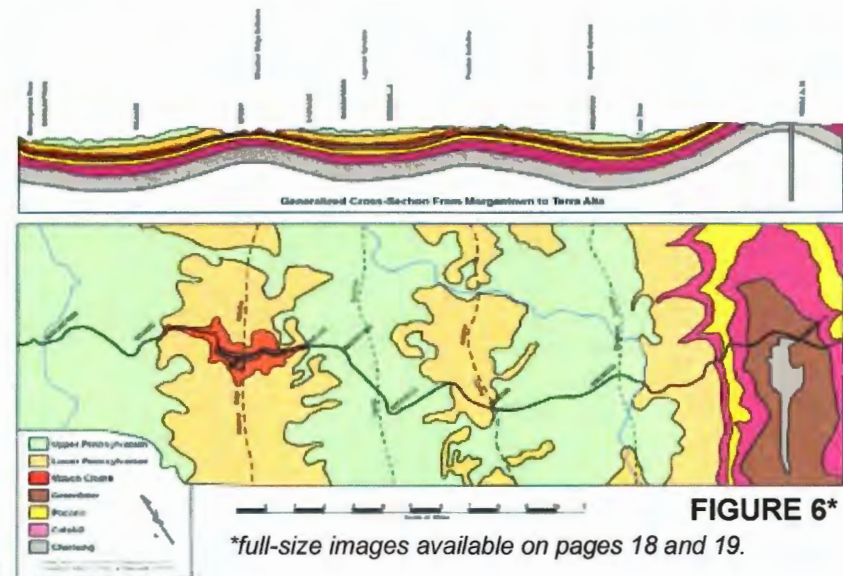


FIGURE 6*

*full-size images available on pages 18 and 19.

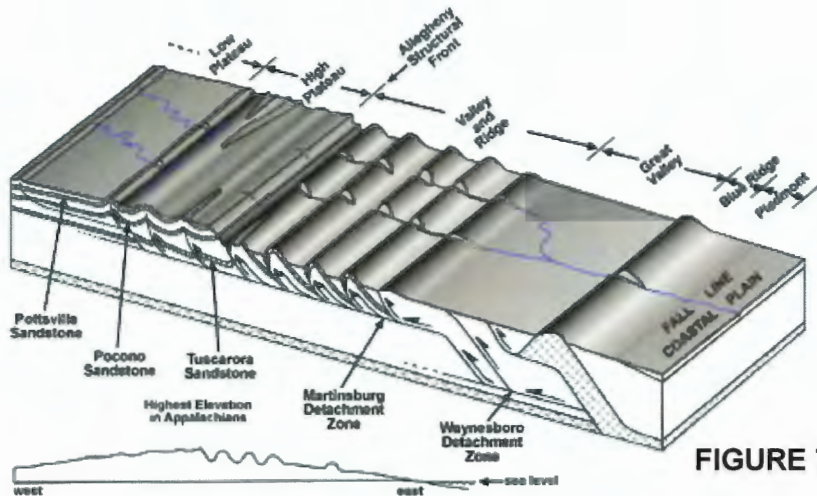
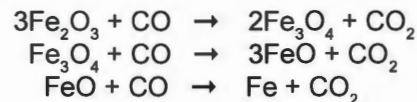


FIGURE 7

Low Plateau and most of the rocks you will see as you cross the High Plateau belong to the Pennsylvanian System which contains the coal beds for which Appalachia is famous. Many of the smaller towns within the region were coal towns. For example, the first small town through which the trip passes, Richard, had a small coking industry during the first half of the last century. Coals mined in the area were roasted in beehive ovens to drive off the volatiles and create coke. Coke is used in the steel industry to separate the iron from the iron ore in blast furnaces. The coke oxidizes in the furnace to produce carbon monoxide, CO , which then reacts with the iron ore, Fe_2O_3 , to release the iron in a molten state:



The ovens were eventually shut down because they became uneconomical to operate and because the vapors generated during the coking process were an environmental hazard.

As the trip crosses Decker's Creek at Dellslow, West Virginia, you are leaving the Appalachian Low Plateau and entering the Appalachian High Plateau (Figure 7). At this point, you are at the western base of the first major structure of the High Plateau, the Chestnut Ridge Anticline. The Chestnut Ridge Anticline extends about 85 miles (137 km) from Uniontown, Pennsylvania, to Weston, West Virginia.

Dellslow, WV to Greer, WV

At Dellslow, the trip enters the water gap that Decker's Creek has cut through the Chestnut Ridge Anticline (refer to Figure 6). The large blocks of rock that appear along the roadway and in the creek were dislodged by physical weathering processes such as frost wedging from the Pottsville sandstone that arches over the Decker's Creek valley. The Pottsville sandstone is the first of several resistant sandstones you will see on the trip. The rock consists of quartz grains tightly cemented together by quartz. In places, conglomerates appear within the sandstone beds. If you've ever been to the overlook at Cooper's Rock, you were standing on the Pottsville sandstone very near the axis of the Chestnut Ridge Anticline, looking down into a classic V-shaped valley carved by the Cheat River. The Pottsville sandstone is the major ridge-former within the High Plateau. As the trip progresses across the High Plateau, you will see exposures of the Pottsville sandstone many times.

Note that as you enter the water gap, the bedding of the rocks dip toward you, meaning that you are approaching the axis of an anticline (Figure 8). As you drive toward an anticlinal axis, the individual rock units are getting progressively older. A geologist would say that you are "going down stratigraphically." As you drive through Decker's Creek water gap, note how narrow the stream appears to be relative to the dimensions of the valley. This points out that, given enough time, a small stream such as Decker's Creek is still a potent agent of erosion.

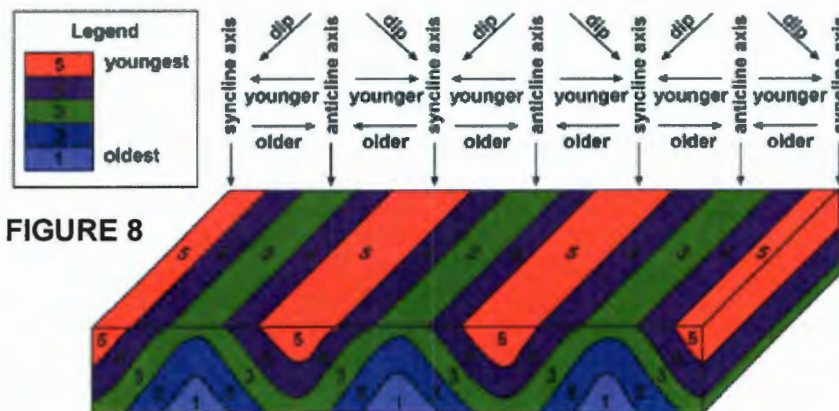


FIGURE 8

As you continue into the water gap, the next rock sequence to appear below the Pottsville sandstone, the Mississippian Mauch Chunk Formation, consists of interbedded sandstones and shales. Unfortunately, the Mauch Chunk is not well exposed along the roadway. The Mauch Chunk Formation is the first of three “red bed” formations you will see today. The red color of the sandstones and shales is due to coatings of hematite, Fe_2O_3 . Geologists interpret the red beds you will see on this trip as indicating that the original sediments were deposited in shallow, highly oxygenate waters that promoted the precipitation of the iron oxides.

As you approach Greer, the road will make a right-angled turn to the left. The rock on your left, looking like a wall, is the Mississippian Greenbrier limestone. The surfaces of the blocks are excellent examples of joints. Joints are breaks in rocks perpendicular to bedding along which there has been no measurable movement. The blocks that you see in the outcrop were formed by the intersection of two sets of mutually perpendicular joints. While all rocks exhibit joints, few are as well exposed as these. The Greenbrier limestone is the oldest rock formation exposed in the Decker’s Creek water gap. Shortly, you will pass the Marquette Cement mine and a mile or so later, the mine of the Greer Limestone Corporation. Both operations are mining the Greenbrier limestone. The rock produced at Greer is largely used for road construction and as the aggregate in concrete. The limestone mined at Greer is also mixed with high-purity limestone from Greer’s Germany Valley quarry and ground into a fine powder to make agricultural lime. Agricultural lime is the white powder you see spread over yards and gardens during the spring to both neutralize the acid soils we have in this region and to provide the calcium nutrients that many of the plants you want to grow in your garden and lawn need; grass being one of them. The trip will visit Germany Valley later in the day.

As you passed through Greer, you crossed the axis of the Chestnut Ridge Anticline. As a result, as you continue through the water gap, you will notice that the bedding of exposed rocks dip away from you, meaning that you are now approaching the axis of the Ligonier Syncline (refer to Figure 8). Because the rock units get progressively younger as you approach a synclinal axis, you are said to be “going up stratigraphically”.

Greer, WV to Reedsville, WV

Beyond Greer, the Pottsville sandstone appears once again along the road as it “comes down” on the east limb of the Chestnut Ridge Anticline. The road map in Figure 1 shows a town called Cascade which no longer exists. Originally, Cascade was the eastern equivalent of Richard in that both used local coals to generate coke in beehive ovens.

Note how the topography becomes more subdued as you drive toward Reedsville and how it resembles the topography around Morgantown. The similarity is an excellent example of how rock type and structure determine topography. The similarity is due to the fact that the same sequence of rocks are exposed in both areas plus the fact that the rock layers are essentially horizontal. In the case of the region near Morgantown the beds are horizontal because it is located in the Low Plateau where the amplitudes of the folds are so low that the bedding is essentially horizontal. In the case of the drive to Reedsville, the rock layers become more horizontal because you are crossing the axis of the Ligonier Syncline. In summary, similar rock types and bedding attitude create similar topography.

Reedsville, WV to Kingwood, WV

At the 4-way stop in Reedsville, turn left toward Kingwood. As the trip continues toward Kingwood, you will note several changes in the landscape. For one, the topography begins to rise and become more rugged. In addition, large sandstone boulders and outcrops of the Pottsville sandstone begin to appear along the roadway and in the fields. The reason for what you see is because you are approaching the axis of the broad Preston Anticline (see cross section in Figure 6). Because the amplitude of the Preston Anticline is nowhere near that of either the Chestnut Ridge Anticline to the west or to those you will see to the east later in the trip, the only affect of the structure is a broad arching of the landscape and an increase in the ruggedness of the topography as the Pottsville sandstone along the axis of the fold begins to be exposed at the surface. However, because the dip on the rocks associated with the broad Preston Anticline are low, the exposure of the Pottsville sandstone

does not form any dominant ridges. As you cross the High Plateau, time and time again you will see the influence of the Pottsville sandstone on the topography. In fact, anytime the topography becomes more rugged and sandstone outcrops appear as you cross the High Plateau, you can count on it being due to exposures of the Pottsville sandstone.

Kingwood, WV to Briery Mountain

As you approach Kingwood, Briery Mountain forms the skyline to the east. At Kingwood, you will cross the Kingwood Syncline and descend to the valley of the Cheat River. At this point, you are at the western base of Briery Mountain. Note from the cross section in Figure 6 that the Briery Mountain Anticline is a very large structure and that it has been "breached". Being breached means that the resistant rocks that formed the crest of an anticline have been removed by erosion, exposing the softer, more easily eroded rocks below. In the case of the Briery Mountain Anticline, the Pottsville sandstone was breached allowing the rocks as old as the Devonian Chemung Formation to be exposed along the axis of the fold (Figure 9).

The large size of the Briery Mountain Anticline, as compared to those that you have crossed up to this point, becomes evident as you

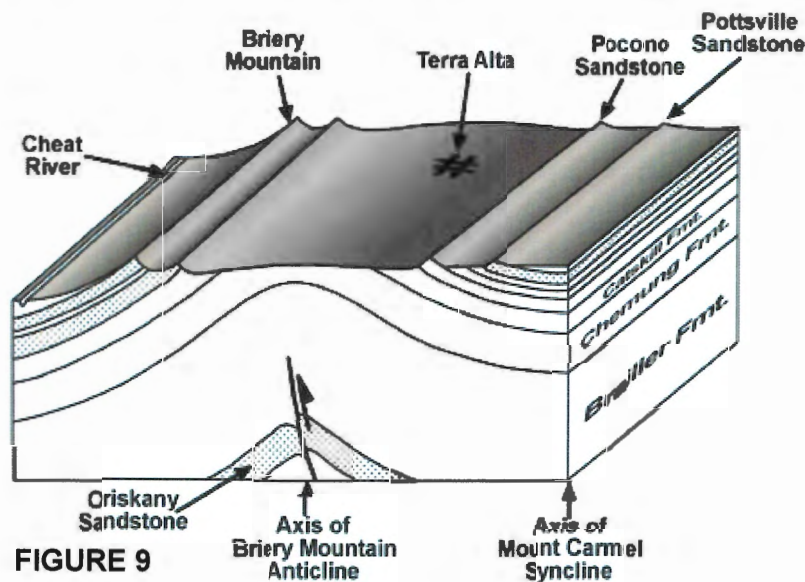


FIGURE 9

climb the long, steep roadway to the top. Because of the breaching of the main structure, Briery Mountain is a monoclinal ridge, that is, it is underlain rock layers that dip in one direction, in this case, to the west. Because the slope of the roadway and the angle of dip of the western limb of the structure are about the same, outcrops of the Pottsville sandstone are more or less continuously exposed along the ascent.

Briery Mountain to Stop #1.

After reaching the top of Briery Mountain at an elevation of 2,704 feet (834 m), the roadway drops into a small valley underlain by the Mississippian Greenbrier limestone. The Greenbrier limestone is the same rock layer mined at the Marquette and Greer mines you passed earlier along Decker's Creek. The valley is an excellent example of how the low resistance of limestone to chemical weathering results in the formation of valleys. Later in the day, you will see two other examples of limestone valleys, Canaan Valley and Germany Valley. The ridge just beyond the small valley is due to the appearance of the next oldest major sandstone unit that you will see today, the lower Mississippian Pocono sandstone. The Pocono ridge, like Briery Mountain, is a monoclinal ridge on the west flank of the breached Briery Mountain Anticline.

After crossing the Pocono ridge, the rocks exposed along the roadway and the soil turn a noticeable red color due to the outcropping of the Devonian Hampshire Formation. The Hampshire Formation is the second of three dominant red bed units you will see today. Beyond the outcrops of the Hampshire Formation, the topography becomes increasingly subdued as you approach the axis of the anticline due to the combination of intermixed, flat-lying sandstones and shales of the Devonian Chemung Formation.

Stop #1

As you crest the hill, the roadway will turn down and to the right. In the bend, there is a pull-off to the left. At this point, stop and walk up through the field to the top of the hill; a distance of a few tens of yards. Assuming that it is a clear day, you will be looking back along the field trip route as it crossed the High Plateau. Not only will you be able to see Chestnut Ridge along the western skyline, but also the topographically lower Preston Anticline between your vantage point and the Chestnut

Ridge Anticline. There are few places where you can get this kind of geologic perspective.

I might also point out that you are standing over the Terra Alta gas field. In its day, the Terra Alta gas field was one of the most productive gas fields in the Appalachians. Today, it is used for gas storage. The local gas company buys gas during the summer when the demand and price is low, pumps it back underground into the original reservoirs for storage, and withdraws it during the winter when demand increases..

Stop#1 to Oakland, Md

From Stop #1, travel eastward through Terra Alta (pronounced by the natives as one word - Tearalta) to Hopemont. As you make the turn to the right at the Hopemont Hospital, the land drops slightly in elevation. At this point, you have dropped off the Pocono ridge on the eastern limb of the Briery Mountain Anticline back down into a Greenbrier limestone valley. The topography here is much more subdued than that which you observed on the western side of the structure because of the lower angle of dip of the eastern limb of the structure. From Hopemont, you will cross the Mt. Carmel Syncline and enter the breached Deer Park Anticline as you continue to Oakland, Maryland (Figure 10). Along the way, you will once again see evidence of the Pottsville sandstone cropping out to the surface and forming the major ridges.

Oakland, Md to Red House, Md

Drive through Oakland on WV Rt. 7 and turn south on US 219 toward Red House. The roadway parallels the axis of the breached Deer Park Anticline. The skyline to the east (your left) is Backbone Mountain, a monoclinal ridge underlain by the east-dipping Pottsville sandstone on the east limb of the structure (refer to Figure 10). The rocks throughout the valley are largely the flat-lying sandstones and shales of the Chemung Formation, once again giving rise to the gently rolling topography.

Red House, Md to the Allegheny Structural Front

At Red House, turn east on US 50. From Red House to Mt. Storm, you will cross the North Potomac Syncline and the Blackwater Anticline (refer to Figure 10). Note how the topography becomes increasingly rough as you drive eastward with the familiar blocks of the Pottsville sandstone beginning to appear along the roadway. What most individuals are not aware of as they drive eastward across Appalachia is the fact that the elevations have progressively increased. The elevation of Morgantown is about 900 feet (275 m) above sea level. By the time you get to Mt. Storm and the Allegheny Structural Front, elevations will have increased to about 5,000 feet (1,525 m) above sea level. The Allegheny Structural Front is the line of demarcation between the Appalachian Mountain Section of the Valley and Ridge Physiographic Province and the High Appalachian Plateau.

Perhaps this would be good time to summarize what you have seen so far. The trip started at the eastern margin of the Appalachian Low Plateau which extends westward to Ohio. Structurally, the Low Plateau is underlain by symmetrical folds with amplitudes so low that the rock beds appear to be horizontal. The rocks throughout the Low Plateau are a mixture of sandstones, shales, and coals. Beginning at Dellslow, you entered the Appalachian High Plateau. While the dominant structures are still symmetrical folds, the amplitudes of most of the folds of the High

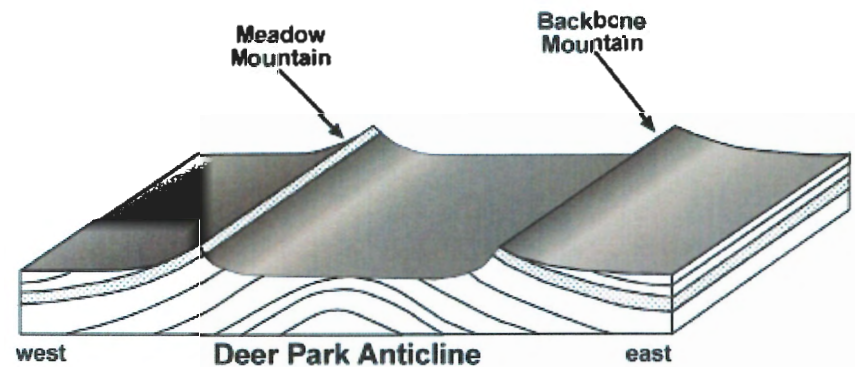


FIGURE 10

Plateau are high enough to produce anticlinal ridges, some of which are breached to form parallel monoclinal ridges. The erosion of the higher amplitude folds brought the resistant Pottsville sandstone to the surface where it was responsible for most of the ridges and much of the rugged topography that characterizes the High Plateau.

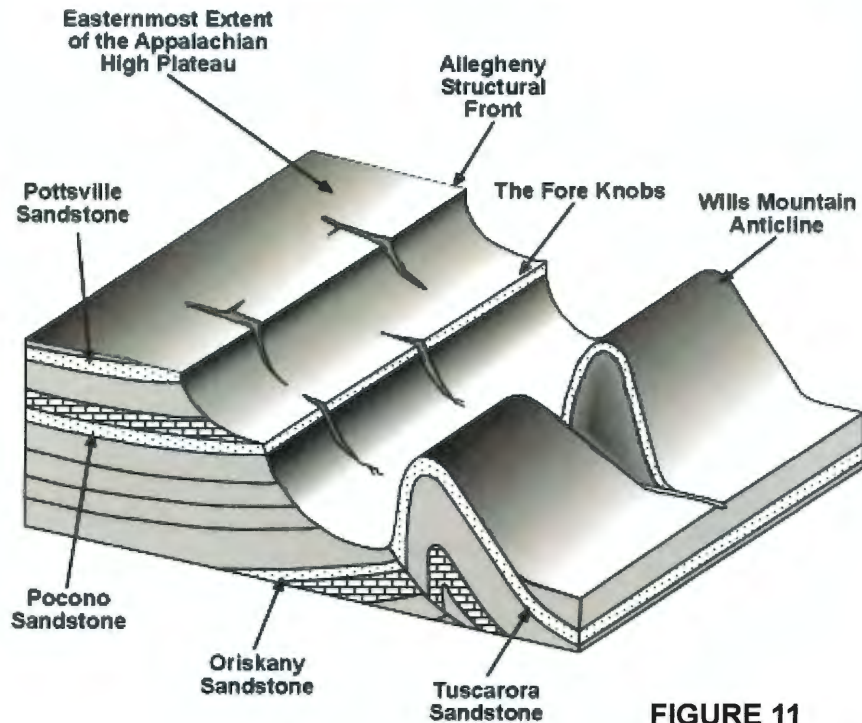


FIGURE 11

Stop #2

Just beyond Mt. Storm, you will arrive at the Allegheny Structural Front (Figure 11). At the very edge of the Front, there is a scenic overlook along US Rt. 50 to the right that will provide you with a spectacular overview of the Appalachian Mountains. The ridge before you is Wills Mountain Anticline, the westernmost structure of the Appalachian Mountain Section of the Valley and Ridge Physiographic Province. On a clear day, you should be able to see several ridges beyond Wills

Mountain to the east. The notch that appears along the summit of Wills Mountain is called a wind gap. A wind gap began as a stream valley that was being carved across an anticline as the region was being uplifted. At some point, however, the rate of down-cutting by the stream was not able to keep up with the rate of uplift of the land. Eventually, the stream separated into two streams flowing down opposite sides of the ridge, leaving a wind gap behind. As a bit of historic trivia, Abraham Lincoln's mother was supposedly born beyond the wind gap on the eastern side of Wills Mountain.

Allegheny Structural Front to WV Rt. 93

You are now about to enter the Appalachian Mountain Section of the Valley and Ridge Physiographic Province. The dominant structures within the Appalachian Mountains are asymmetric to slightly overturned anticlinal folds, with the steep western limb commonly broken by high-angle thrust faults (Figure 12). Most of the mountains consist of long narrow anticlinal ridges capped by the Silurian Tuscarora sandstone with the adjoining synclinal valleys underlain by soft Devonian shales. As was the case with the High Plateau, many of the anticlinal structures are breached, forming monoclinal ridges on opposite sides of valleys underlain by Ordovician limestones.

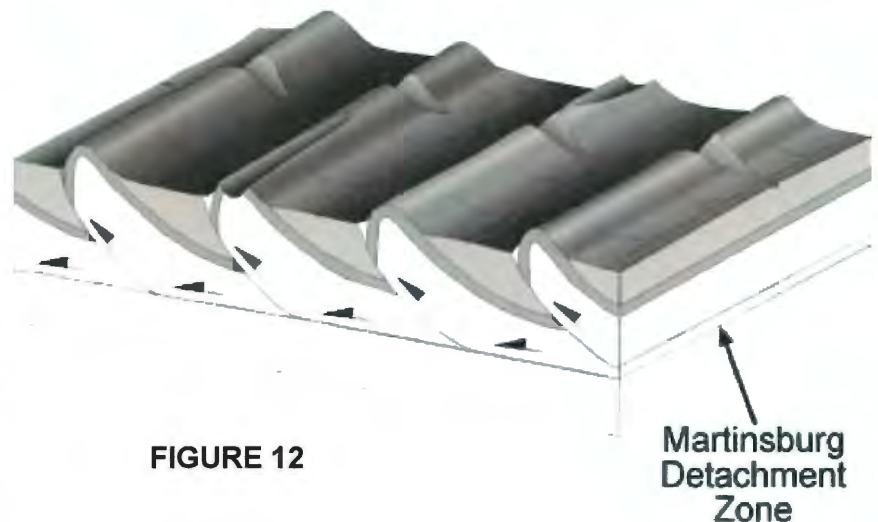


FIGURE 12

Continue on US Rt. 50 beyond the Front. As you descend the Front, you will drop below the Pottsville sandstone that caps the edge of the Front and pass through the red beds of the Mauch Chunk Formation. After passing through most of the Mauch Chunk red beds, the roadway encounters a relatively flat ledge known as the Fore Knobs (refer to Figure 11). The Fore Knobs are held up by the second resistant sandstone you saw on Briery Mountain, the Pocono sandstone. Above the Pocono is the Greenbrier limestone which accounts for most of the Fore Knobs being a grassy pasture. The dissolution of the limestone provides the calcium ions that grass prefers as a nutrient. During the early settlement of the region, the pastures of the Fore Knobs were supposedly used to graze cattle.

At this point in your descent from the Front, you will see a sign warning truck drivers to "stay in low gear". All too often, truckers unfamiliar with the road reached the flattened portion of the roadway on the Fore Knobs after dark and considered that they have completed the descent from the Front and shift to high gear. Unfortunately, the worst grade is yet to come. Once beyond the Fore Knobs, the roadway descends steeply through the red beds of the Hampshire Formation, the sandstone and shales of the Chemung Formation, the rust-colored shales and sandstones of the Brallier Formation and at the bottom of

***** A word of caution: Because of the steep grades and hairpin turns, this stretch of road is extremely dangerous. Keep in mind that historically the main cause of accidents has been brake failure. I want you to enjoy the geology and the scenery, but not at the price of your life ***.**

the grade, the black shales of the Hamilton-Marcellus Formation. Note that as you descend from the Fore Knobs, the beds begin to dip toward you at progressively increasing angles from nearly horizontal at the Pocono outcrop to very steep at the bottom of the grade. This increase in dip reflects your approach to near-vertical western limb of the Wills Mountain Anticline.

WV Rt. 93 to Scherr, WV

At the intersection of US 50 and WV Rt 93, turn south on WV Rt. 93 to Scherr. You will be driving down a valley underlain by the black shales of the Devonian Hamilton-Marcellus Formation. The Hamilton-Marcellus Formation underlies most of the synclinal valleys in the Appalachian Mountains. Several places along the roadway, the Devonian Oriskany sandstone forms a small anticlinal structure called the Hopewell Anticline, on the western flank of the main Wills Mountain Anticline.

The Oriskany sandstone has played an important economic role in West Virginia. Within the Appalachian Plateau, the Oriskany sandstone reservoir produced more petroleum during the early years of the petroleum industry than any other single reservoir. For example, the Oriskany was the source of gas in the Terra Alta field. In most cases, the Oriskany sandstone is a calcareous sandstone which means that the quartz grains are cemented together by calcite, CaCO_3 . At a quarry outside Berkeley Springs, West Virginia, however, the Oriskany is an ultra-pure quartzose sandstone with the quartz grains cemented by quartz. Sandstone from the quarry have long been used for the production of fine glass and crystal. In fact, it was Oriskany sandstone from the Berkeley Springs quarry that Corning Glass used to cast the glass disc that was used to make the reflecting mirror for the Mt. Palomar telescope.

Scherr, WV to Maysville Gap

At Scherr, continue southward on WV Rt 42 toward Maysville and Petersburg. Just south of Scherr, WV Rt. 42 will turn east into Maysville Gap, a water gap carved through Wills Mountain Anticline. As you enter the gap, you will have your first view of the Tuscarora sandstone exposed in the nearly vertical western limb of the structure. The Tuscarora sandstone is the major ridge-former throughout the Appalachian Mountains. As you pass through the gap, the Tuscarora can be seen to arch high above the valley floor. The sides of the gap are covered with scree consisting of blocks of rock broken from the

Tuscarora cliffs above. At places along the roadway, you will be able to see outcrops of the third major formation of redbeds, the Juniata Formation, that underlies the Tuscarora sandstone. As you near the eastern end of the watergap, the Tuscarora sandstone forms some spectacular waterfalls. If you have time, stop within the gap and enjoy the beauty of the geology and of the stream.

Maysville Gap to Petersburg, WV

As you emerge from the eastern end of Maysville Gap, you will notice the more gently-dipping eastern limb of the structure as the Tuscarora sandstone returns to road level. Comparing the attitudes of the vertical western limb and the more gentle eastern limb gives you a feeling for the asymmetry of the structure. Shortly beyond the Tuscarora outcrop, you will once again encounter the Oriskany sandstone, this time in the form of a monoclinical ridge called a hog back. Beyond the Oriskany ridge, you will enter a synclinal valley between the Wills Mountain Anticline to the west and the Patterson Creek Anticline to the east. The valley is underlain by shales of the Brallier and Hamilton-Marcellus formations.

Locally, this valley is known as “The Barrens” or “The Shale Barrens” because of its scarcity of trees. The reason for the lack of large plants is because, being located in the rainshadow of both the Front and Wills Mountain, the annual precipitation for the valley is less than 20 inches (50 cm). According to my botanist friends, 20 inches of annual precipitation is the absolute minimum for the survival of most trees. While the valley certainly doesn’t qualify as a desert, as you drive southward, keep an eye out for cacti that commonly grow along the fence lines.

Petersburg, WV to North Fork Gap

Driving south, the roadway parallels the monoclinical Oriskany ridge and Wills Mountain. Just outside Petersburg, turn west at the intersection with WV Rt. 28 toward North Fork Gap. As you drive toward the gap, you will be able to clearly see the monoclinical Oriskany ridge in the foreground and the Tuscarora sandstone arching high over the gap. The Allegheny Structural Front makes up the skyline to the west. The

next stop, Dolly Sods, is located along the portion of the Front that you can see beyond the water gap.

North Fork Gap to Dolly Sods

As you exit North Fork Gap, you will once again see the vertical western limb of the Tuscarora sandstone. To your right, you will pass Smoke Hole Caverns which are commercial caves within the vertical outcrop of the Silurian Tonoloway limestone. The Oriskany sandstone will once again appear along the roadway. After a mile or so, Jordan Run Road will enter on your right. Turn right onto Jordan Run Road and bear left at the intersection. Over the next few miles, you will re-climb the Front. Try to identify the various rock units along the way. You should be getting pretty good at recognizing many of the rock units by now.

Once on top of the Fore Knobs, the road will run parallel to the Front for a few miles. There are several places along the roadway that you may want to stop and just enjoy the scenery and think about all of the geology that you have seen.

Stop #4: Dolly Sods

As you reach the summit of the Front, you will come to a T-intersection. Turn right and after a few yards, pull off the road and park at an information board that will give you the usual historical information about the area. Do not go to the “official” overlook which is further down the road; there is one that is infinitely better. Facing east, you will see a line of conifers that come out nearly to the road. To the left is an open area of low bushes and brambles. Keeping the conifers to your right, head out across the open area. As you cross the area, you will see a low-growing plant commonly called “ground pine”. This plant is the only descendent of a once majestic tree, *Lepidodendron*, that 300 million years ago was a major contributor to the peats that eventually became the coals of the eastern United States. You will see some fossil remains of *Lepidodendron* later at a stop on Canaan Mountain.

On your way to the edge of the Front, you will encounter large tilted blocks of the Pottsville sandstone. The most widely held explanation for their origin is that during the maximum advance of the Pleistocene ice sheet, which never got anywhere near where you are, the peri-glacial

climatic conditions that existed throughout most of Central and Northern Appalachia resulted in intense frost wedging the broke the layers of Pottsville sandstone that were exposed at the surface into blocks and left them in the jumbled array you now see. Within a hundred yards or so, you will come to the very edge of the Allegheny Structural Front where you can sit on the Pottsville outcrop that makes up the edge of

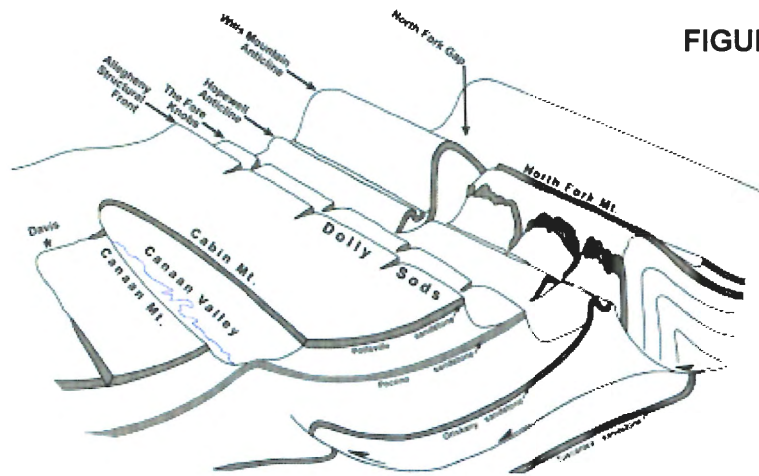


FIGURE 13

the Front and dangle your legs over the edge. I have provided a block diagram of the area for you to illustrate all that you will see from this vantage point (Figure 13).

Behind you, the Appalachian High Plateau stretches away to the west with Cabin Mountain making up the skyline. Beyond Cabin Mountain lies Canaan Valley and Canaan Mountain, both of which you will visit later in the trip. This place is called Dolly Sods after the Dolly family that settled here. Can you imagine what it must have been like living along the Front during those early days? The stunted growth of trees clearly indicates it experienced severe weather. Having made a winter backpacking trip onto the Sods, I can attest to how cold it can get. The trees with limbs only on the eastern side attests to the strong westerly winds that commonly whip the area. You should not be surprised to be told that another name for this place is "The Roaring Plains".

The reason for coming to this spot is the view to the east. Before

you is the most spectacular view of the Valley and Ridge Province I have ever seen. It almost speaks for itself. This place is what geology is all about. On a clear day you can see several ridges beyond Wills Mountain. Looking back through North Fork Gap toward Petersburg, note that the Tuscarora sandstone on the north side of the gap arches unbroken across the entire ridge. To the south of the gap, however, the structure has been breached with the Tuscarora sandstone having been eroded away along the summit. The outcrop of the Tuscarora along the eastern limb of the structure continues southward as North Fork Mountain while, along the western side of the structure, the Tuscarora sandstone forms a series of vertical outcrops separated by V-shaped notches carved out by streams flowing off the western side of the mountain. But why is the southern portion of the anticline breached while the northern portion is not? There is evidence that many, if not most, of the water gaps cutting across the ridges of the Appalachian Mountains are the sites of vertical faults that actually provided the zones of weakness sought out by the streams to carve their channels when the region was uplifted over the past 60 million years. In the case of North Fork Gap, the southern side of the fault was uplifted more than the northern side, resulting in the southern portion of the structure experiencing more intense weathering and erosion than the northern portion of the structure. Eventually, the combined efforts of physical weathering, mass wasting and erosion carved through the Tuscarora along the entire summit of the ridge.

Dolly Sods to Mouth of Seneca, WV

Before we leave Dolly Sods, I want to describe another way to exit or gain access to Dolly Sods. The trip will leave Dolly Sods by turning left at the T-intersection and returning to the Jordan Run Road intersection. Another way to leave is to go straight ahead at the T-intersection, drop down to Red Creek Valley, continue through Laneville, and intersect with WV Rt. 32. If you turn right onto Rt 32, you will enter the southern end of Canaan Valley in a mile or two. If you want to access Dolly Sods from Canaan Valley, head south from the valley and take the Laneville Road to the T-intersection at Dolly Sods. For those of you who are backpackers and want a beautiful two-day hike, the Red Creek backpacking trail starts at the Forest Service building near the bridge crossing Red creek, loops up and through Dolly Sods, and returns to the service building.

Leave Dolly Sods and retrace your path back to Jordan Run Road and WV Rt. 28. At WV Rt. 28, turn right and head south to Mouth of Seneca. Along the way, you will see some spectacular outcrops of both the Oriskany and Tuscarora sandstones.

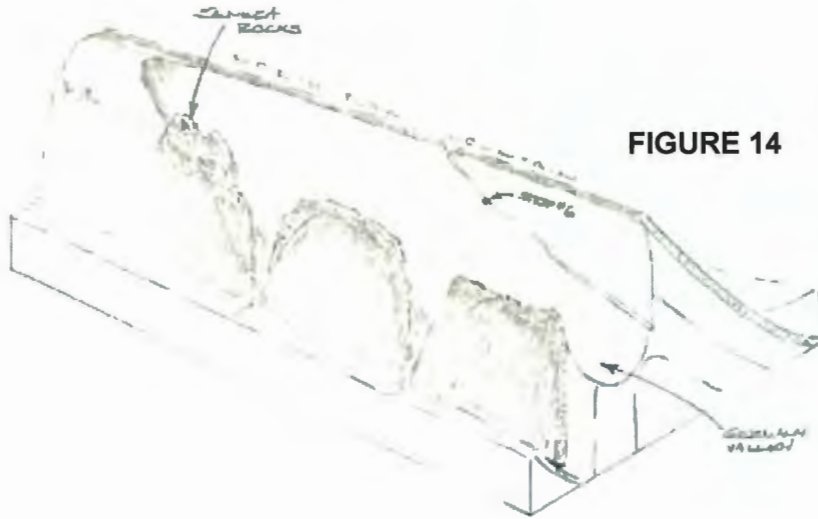


FIGURE 14

Stop #5: Mouth of Seneca, WV

Seneca Rocks, a well-known tourist spot, is the vertical outcrop of the Tuscarora sandstone exposed in the western limb of the Wills Mountain Anticline. Invariably, you will see rock climbers on the front face of the outcrop (Figure 14). During World War II, the Army used the rocks to train their commando troops in rock climbing.

Just beyond the intersection is a driveway leading to a Forest Service Information Center. If you feel ambitious, a climb to the top of Seneca Rocks is in order. A path to the top of the outcrop begins at the visitors center and ascends the front face of the outcrop. While the hike will take about an hour, it is worth the time. As you climb, take time to observe the Tuscarora sandstone. I think you can see why the Tuscarora is the major ridge-former in the Appalachian Mountains. There aren't many rocks more resistant to weathering and erosion than this one.

A second way to the top is by crossing North Fork and taking a road that leads through the water gap at the southern edge of Seneca Rocks (Stop #6). Once through the gap, a path takes off to the left and begins the climb to the top. The red rocks you will be climbing on belong to the Ordovician Juniata Formation which is the third and oldest of the three red beds that you will encounter during the trip. Once at the top, you'll be 900 feet (277 m) above the valley floor. Behind you will be the northernmost end of Germany Valley. You will get a better view of Germany Valley at a later stop on North Fork Mountain. In front of you will be the Allegheny Structural Front. Dolly Sods will be just barely within your line of sight along the Front to the north. The highest point in West Virginia, Spruce Knob at 4,863 feet (1,482 m) will be just out of sight along the Front to the south. As you look due west, you will see a small stream that has carved its channel back into the edge of the Front. On your return to Morgantown, you will follow this stream valley back up onto the Front. A note of caution. Be careful while you are on the summit of Seneca Rocks; too many lives have been lost by falling from the top.

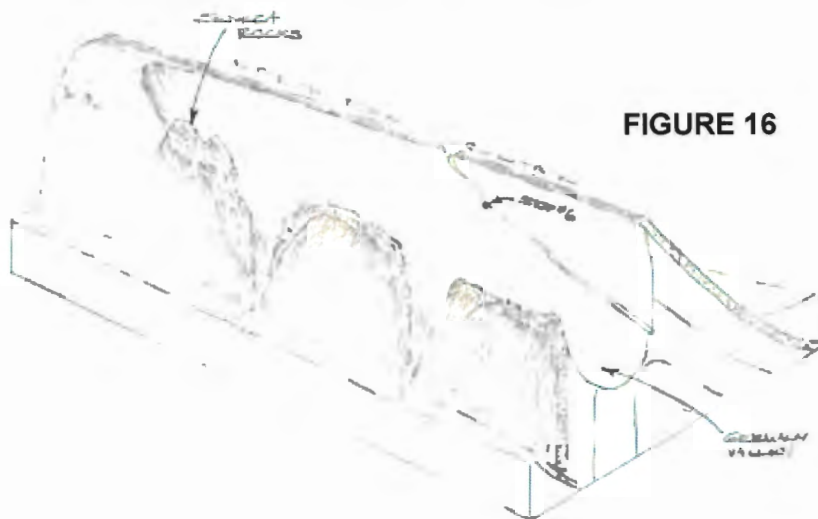
Mouth of Seneca, WV to Seneca Caverns

Continue south on WV Rt. 33 toward Riverton. (If you are interested in going into a commercial limestone cavern, turn right at Riverton and follow the road to Seneca Caverns.) Along the way, you will pass sinkholes where the limestone has been dissolved along the intersections of two sets of joints (Figure 15). Caverns form as groundwater dissolves limestone along fractures and joints. The limestones in this case are



FIGURE 15

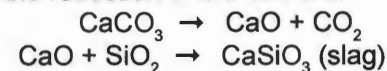
the Ordovician Black River and Stones River formations. Even if you don't choose to enter the caverns, along the way you will be able to see excellent examples of sinkholes that characterize karst topography that commonly forms in regions underlain by limestones.



Seneca Caverns to North Fork Mountain: Stop #7

Return to Riverton and continue south on WV Rt. 33, passing through Judy Gap and into Germany Valley. As you climb the western flank of North Fork Mountain, you will have a truly spectacular view of Germany Valley. Near the top of North Fork Mountain, there will be a pull-off to the left which will be Stop #7 (Figure 16). From this vantage point, Seneca Rocks can be seen to your right at the very head of the valley. To the south of Seneca Rocks, you can see similar, but not so spectacular, outcrops of the Tuscarora sandstone along the vertical western limb of the structure and their associated V-shaped water gaps. Looking northward along the strike of North Fork Mountain, you can see the eastward dipping outcrop of the Tuscarora sandstone along the crest of the ridge. Imagine that at a point in time, the Tuscarora sandstone along North Fork Mountain arched up and over what is now Germany Valley and connected with the vertical outcrop of the Tuscarora

sandstone along the western limb of the anticline. Once the combination of physical weathering, mass wasting and erosion breached the resistant Tuscarora sandstone south of North Fork Gap and exposed the soft sandstones and shales of the underlying Juniata Formation, Germany Valley began to form. Eventually erosion carved through the Juniata and Martinsburg formations, exposing the underlying Ordovician limestones that now form the valley floor. Greer Limestone's Germany Valley quarry can be seen toward the northern end of the valley. According to their estimates, at the present rate of production, Greer has enough high-quality limestone in the quarry to last for 500 years before they go underground. Obviously, Greer Limestone Corporation plans to be in business for a long time. Most of the limestone Greer produces from the Germany Valley quarry is used in blast furnaces to remove silica contaminants during the reduction of the iron ore:



It is also blended with the more magnesium-rich limestones from their operation at Greer to make agricultural lime.

If you're interested in fossils, you might investigate the outcrop of the Martinsburg Formation directly across the road from the overlook. The rocks are quite fossiliferous and you should have no trouble finding a variety of marine fossils. While most will be fossilized shells, if you're lucky, you may find a trilobite or two. A word of caution. Because the outcrop is located in a bend in the road, stay well away from the edge of the pavement and always have someone on the lookout to warn you of oncoming traffic.

While you are at this vantage point, I think it is interesting to point out that the sequence of rocks you see, from the Ordovician Black River and Stones River limestones that underlie the floor of Germany Valley to the Pennsylvanian Pottsville sandstone that outcrops along the Front, represents about 200 million years of Earth history. When the carbonate sediments that formed the Ordovician limestones rocks were being deposited, the first vertebrates were evolving in the form of jawless fish. By the time the Pottsville sediments were being deposited during Pennsylvanian time, animal evolution had advanced all the way through the amphibians to the first reptiles. While there was no life on land during Ordovician time, it began to appear during Devonian time and by the Pennsylvanian, the land was covered with forests. This was a time

when the vast swamps that accumulated the peat that would eventually be converted into our eastern coals covered the land. Amphibians dominated the swamps while early reptiles ventured onto the land. In addition, the Pennsylvanian Period has often been called the "Age of the Insect" when dragonflies with three-foot wingspans droned through the forests and swamps and foot-long cockroaches scurried about on the forest floor.

North Fork Mountain to Spruce Knob (Stop #8) to Mouth of Seneca, WV

Retrace the route back through Judy Gap and head north on WV Rt. 33. About a mile or so north of Judy Gap, the road to Spruce Knob turns off to the left. There isn't a lot to see at Spruce Knob. Although you will be on the edge of the Front, the view is not as spectacular as that from Dolly Sods. If you want to be able to say that you visited the highest point in West Virginia, by all means, go. It will take about an hour for the trip up and back. Otherwise, continue north on WV Rt. 33 to Mouth of Seneca.

Mouth of Seneca, WV to Harman, WV

At Mouth of Seneca, turn left and follow WV Rt. 33 toward Harman. For those who are backpackers, just west of Mouth of Seneca, a road to the left leads to the Seneca Creek Campground. A trail begins at the campground and ends up at Judy Springs Campground on Spruce Knob. The trail is a very easy hike and is quite scenic. While a round trip can be made in a long day, I would recommend making it a two-day trip with an overnight stay at Judy Springs Campground.

As you continue on WV Rt. 33 toward Harman, you will climb back up onto the High Plateau. However, because you followed a stream that had incised its channel back into the plateau, you will emerge onto the plateau several miles west of the Allegheny Structural Front. As you make the climb, see if you can identify the rock formations you pass. The red beds should give you an idea as to where you are stratigraphically as you make your way to the top. The western headwaters of these

eastward-flowing streams represents the Eastern Continental Divide. Streams that headwater east of the Divide, such as the Potomac River, flow to the Atlantic while those the headwater west of the divide flow to the Gulf of Mexico via the Ohio and Mississippi rivers.

Harman, WV to Canaan Valley

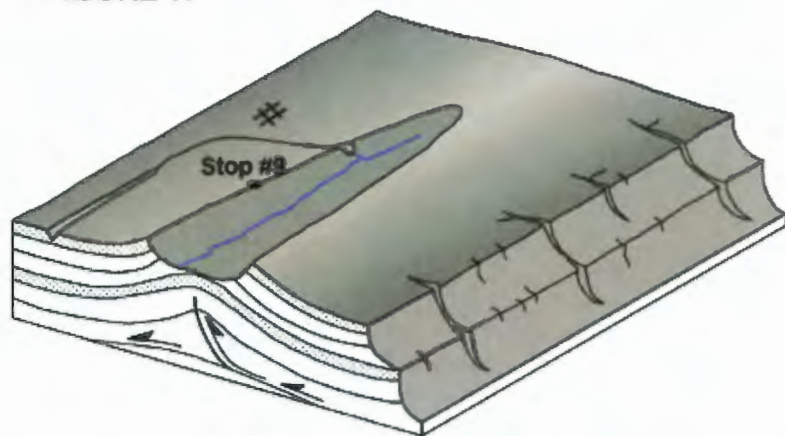
At Harman, turn right on WV Rt. 32. Just before you enter the southern end of Canaan Valley, you will pass the road leading to Laneville that I suggested was an alternative route to or from Dolly Sods. Immediately past the intersection, you will see the vertical outcrops of the Greenbrier limestone. Canaan Valley was formed by the breaching of the Blackwater Anticline. As you enter Canaan Valley, the entrance to Canaan Valley State Park is to the left and the entrance to Weiss Knob ski slopes is to the right. As you continue northward through the valley, you are driving parallel to the axis of the breached Blackwater Anticline. Canaan Mountain along the western side of the valley and Cabin Mountain along the eastern side are monoclinal ridges held up by outcrops of the Pottsville sandstone. Outcrops of the Greenbrier limestone that underlies the valley floor can be seen in the road cuts. The Pocono sandstone just barely comes to the surface along the axis of the structure. The Blackwater River headwaters in the southern portion of the valley and crosses the roadway at a small culvert. You will recognize it by the number of parked cars belonging to fishermen. I have NEVER come through the valley when there weren't fishermen in the stream. What has always amazed me is that the stream at that point is about four feet wide and two feet deep. Eventually, the river will leave the valley following a water gap through Canaan Mountain near the northern end of the valley.

Canaan Valley to Canaan Mountain: Stop #9

Toward the northern end of the valley, the roadway crosses the valley and begins to climb Canaan Mountain. The redbeds that appear along the roadway belong to the Mauch Chunk Formation. Just before you reach the top of the mountain, Stop #9 will be at a pull-off to the right.

You are again standing on the Pottsville sandstone looking across the valley to Cabin Mountain (Figure 17). Imagine the Pottsville sandstone arching over the valley and connecting with the Pottsville outcrop along Cabin Mountain. Your stop at Dolly sods is directly east of your present location beyond Cabin Mountain. The northern end of Canaan Valley

FIGURE 17



is an uninhabited swamp-marsh-bog complex. Botanist friends tell me that the plant community within the northern portion of the valley is very unique. Tundra and taiga plants growing there are leftovers from the periglacial climates that characterized the region during the maximum advance of the Pleistocene ice sheet which, for this region, was just south of the Pennsylvania-New York state lines. .

Directly across the road from the stop, the outcrop of the Pottsville sandstone may provide some excellent fossils of the types of plants that formed the coals for which West Virginia is famous. If you are interested in plant fossils, you might consider buying a publication available from the West Virginia Geologic and Economic Survey entitled "*Plant Fossils of West Virginia*" by Bill Gillespie, John Clendenning, and Herman Pfefferkorn. It's about as complete a treatment of Pennsylvanian fossil plants that you'll find anywhere. The fossils you will find at this site include a variety of leaves of the so-called "tree ferns" that were not true ferns but rather were seed bearers whose fronds resembled ferns. The



FIGURE 18

major plants growing during Pennsylvanian time include *Calamites* whose stem looks like bamboo, and *Lepidodendron*, and *Sigillarian* whose stem impressions look like the diamond pattern of a doormat (Figure 18, from "*Plant Fossils of West Virginia*"). The difference between the two fossils is that the diamond pattern spirals around the stem in lepidodendrons while it is aligned parallel to the stem in sigillaria. The stem of *Calamites* looks like the segmented stems of bamboo.

Canaan Mountain to Blackwater Falls State Park Stops #10 & #11.

Continue toward Davis, West Virginia. As the roadway descends from Canaan Mountain, the slope of the roadway follows the gentle slope of the west limb of the Blackwater Anticline. Note also the numerous blocks of Pottsville sandstone, the rugged topography, the sandy soil, and the dominance of conifers along the way. You will cross the Blackwater River just as you enter Davis. Just west of Davis, turn left onto the access road to Blackwater Falls State Park. Follow the road until it ends in the parking lot for the overlook located directly across the gorge from the lodge.

Stop #10

Stop #10 will be at the overlook (Figure 19). After leaving Canaan Valley, the Blackwater River flows westward to Davis where it turns southward, eventually flowing into the Cheat River. Along the way, the stream carved the gorge you see before you. At this point, you are standing on the Pottsville sandstone at the edge a youthful V-shaped stream valley that is 485 feet (148 m) deep. The gorge has often been referred to as the "Grand Canyon of the Blackwater". The dark color of the water is due to the tannic acid that is released by the decay of the leaves and bark of the hemlock trees that abound in the area. While the tannic acid does add an interesting flavor to the water, to my knowledge, the water isn't harmful to drink. During the early part of the last century, Davis and a nearby town, Thomas, were centers for the tanning of leather, primarily because of the local availability of tannic acid.

Stop #11

Backtrack along the access road to the parking lot serving the Falls. Blackwater Falls speaks for itself. Most individuals are unaware that waterfalls are very ephemeral features; geologically, they don't last very long. As you stand at the falls, note the shapes of the rocks at the base of the Falls. I think you can see where, based on their shapes,

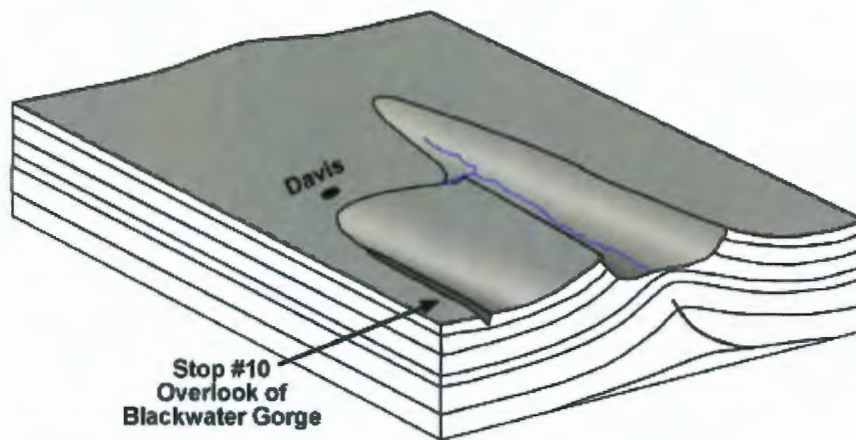


FIGURE 19

that the rocks came from the lip of the falls. Over time, as the softer underlying rocks are eroded, support for the outcrop of the sandstone that makes up the lip of the falls is removed. Lacking support, the sandstone along the lip of the falls breaks away, resulting in the slow retreat of the falls upstream upstream (Figure 20). As falls retreat and decrease in height, they eventually are turned into rapids which, in turn, are reduced to mere riffles in the stream. As you observe Blackwater Falls, keep in mind that they originated downstream where the Blackwater River flowed into Cheat River.

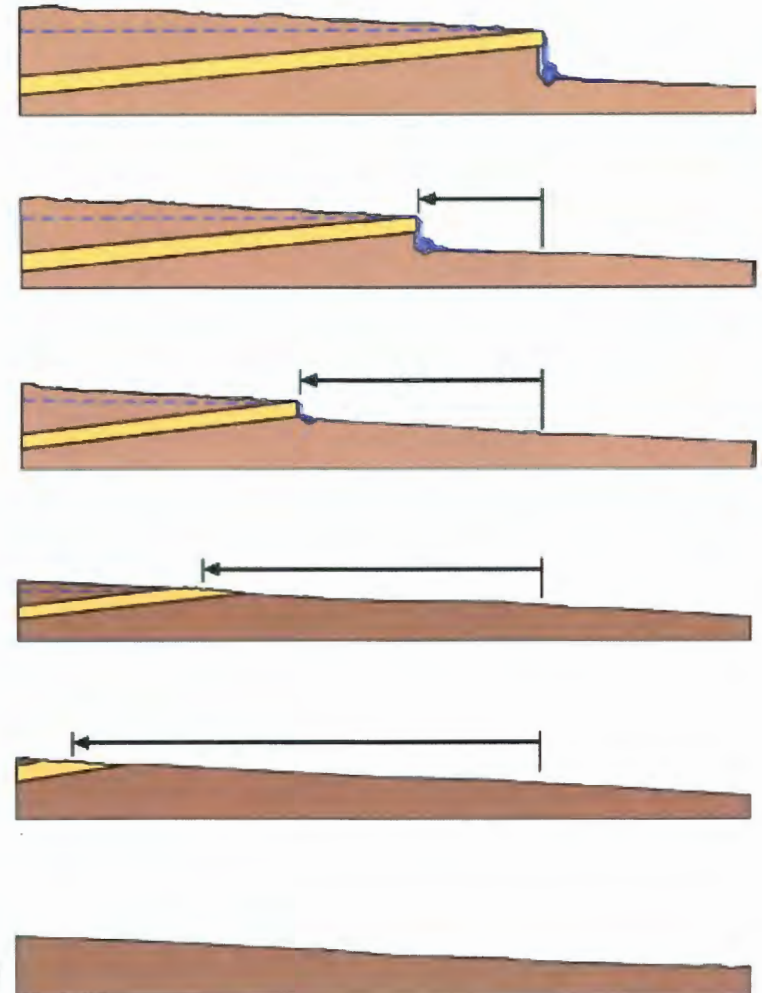


FIGURE 20

Blackwater Falls State Park to Backbone Mountain Stop #12

Leave Davis, West Virginia, and head west through Thomas, West Virginia. Take WV Rt. 219 out of Thomas through Fairfax Stone. Just west of Fairfax Stone, the roadway begins to descend Backbone Mountain. Part way down the mountain, turn off to the left at a scenic overlook. At this point, you are on the eastern limb of the breached Deer Park Anticline, the same structure you crossed at Oakland, Maryland (refer to Figure 10). From the overlook, your view is across rolling terrain underlain by the Chemung Formation. As you've seen before, this type of topography is expected where the underlying rocks are a mixture of sandstones and shales and where the bedding along the axis of the structure is relatively flat lying. The western limb of the breached structure can be seen along the western skyline.

Backbone Mountain to Morgantown, WV

Continue to Silver Lake. Turn left onto WV Rt. 24 which is a shortcut to U.S. Rt 50. Turn left on US Rt. 50. Follow US Rt. 50 through Fellowsville to WV Rt. 92 North. Follow WV Rt. 92 to Reedsville. At Reedsville, take WV Rt. 7 back to Morgantown. I sincerely hope that this trip has not only been enjoyable but has developed in you a better understanding and appreciation of the geologic processes that constantly shapes the land around us.

I-68/I-70: A WINDOW TO THE APPALACHIANS

by

Dr. John J. Renton
Dept. of Geology & Geography
West Virginia University
Morgantown, WV

Introduction

The Appalachian Mountains are probably the most studied mountains on Earth. Many of our modern ideas as to the origin of major mountain systems evolved from early investigations of the Appalachian region. The Appalachians offer a unique opportunity to experience the various components of an entire mountain system within a relatively short distance and period of time. Compared to the extensive areas occupied by other mountain systems such as the Rockies and the Alps, the Appalachians are relatively narrow and can be easily crossed within a few hours driving time. Following I-68 and I-70 between Morgantown, WV, and Frederick, Maryland, for example, one can visit all of the major structural components within the Appalachians within a distance of about 160 miles.

Before I continue, I would like to clarify references to the Allegheny and Appalachian mountains. The Allegheny Mountains were created about 250 million years ago when continents collided during the Alleghenian Orogeny to form the super-continent of Pangea (**Figure 1**). As the continents collided, a range of mountains were created in much the same fashion that the Himalaya Mountains are now being formed by the collision of India and Asia. About 50 million years after its



Figure 1

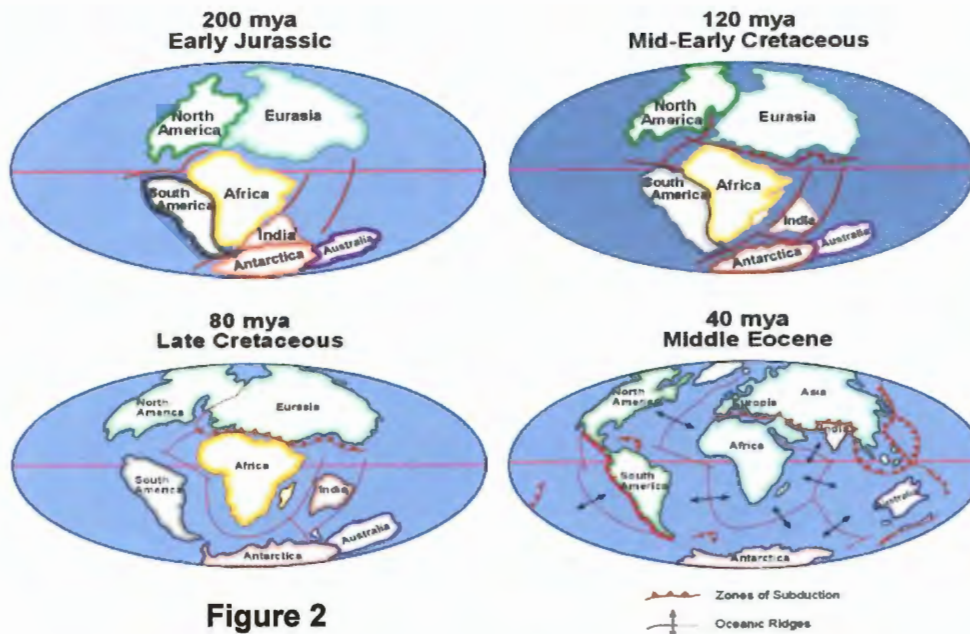


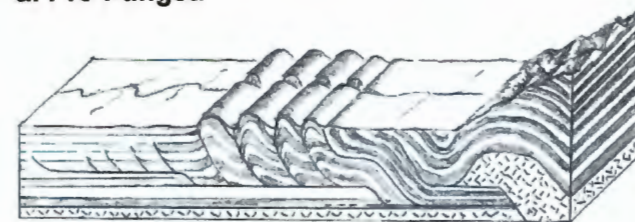
Figure 2

with some of the rocks exposed in Europe from northern Ireland through Scotland to Scandinavia. Over the next 100 million or so years, the combined efforts of weathering, mass wasting, and erosion wore the topography of the original Allegheny Mountains down to a flat, featureless plain nearly at sealevel. About 60 million years ago, the entire eastern portion of North America from the continental interior to the east coast was uplifted into a broad arch with the apex rising about 5,000 feet (1,525 m) above sea level. As the existing streams, rejuvenated by the uplift, began to carve their channels down to the newly formed baselevel, the present topography of the Appalachian region emerged. A schematic representation of the evolutionary history of the Appalachians is illustrated in **Figure 3**. It is important to keep in mind as you traverse the Appalachians along the route of I-68 and I-70 that the *structures* you see, the folds and faults, are very old, dating back to the Alleghenian Orogeny 250 million years ago, while the present *topography* of the region we now know as the Appalachian Mountains is the result of erosion that has taken place over the past 60 million years.

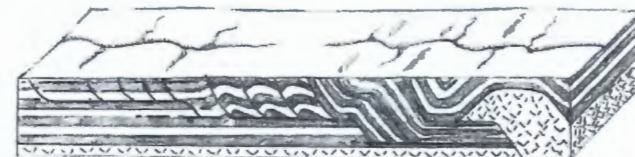
creation, Pangea began to break up with the break occurring parallel to the axis of the original mountains. As the pieces that were to become our present continents moved away from each other, the Indian, Atlantic, and Arctic oceans were created (**Figure 2**). As North America split away from Europe and North Africa, part of the mountain chain went with North America to eventually become our present Appalachians while the rest of the mountain chain remained with Africa and is now to be found in North Africa as the Atlas Mountains



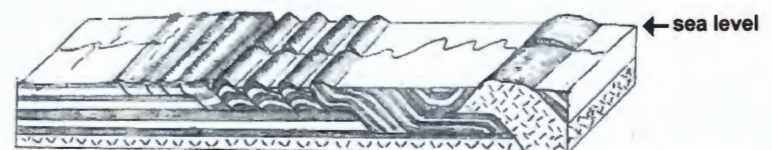
a. Pre-Pangea



b. 250 MYA - The Formation of Pangea



c. 100 MYA - After Formation of Pangea



d. After uplift and Erosion

Figure 3

Basic Geologic Information and Principles

In order to help you better understand what you will see along the route of the trip, I have included a review of some basic geologic topics.

Geologic Structures: The geologic structures are *folds*, *faults*, and *joints*. The dominant structures you will see during this field trip are folds. Based on their shape, folds are divided into *symmetric*, *asymmetric*, *overturned*, and *recumbent* (Figure 4).

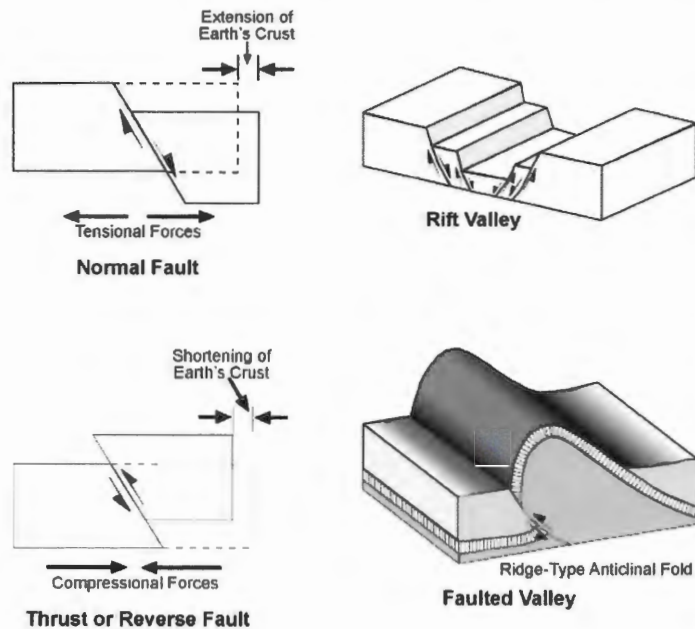


Figure 5.

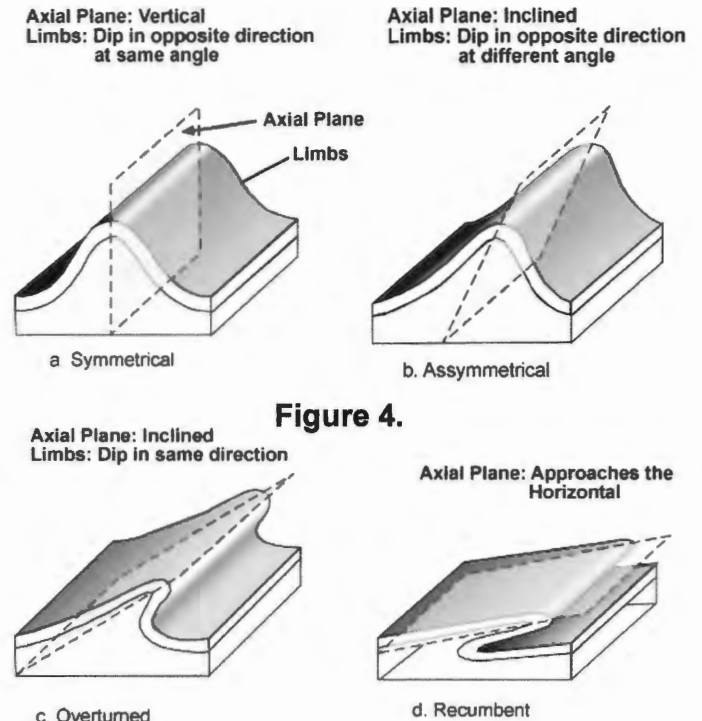


Figure 4.

Three criteria are used to describe the shape of folds: 1) the attitude of the *limbs*, 2) the attitude of the *axial plane*, and 3) the angle, called the *dip*, that the limbs make with the horizontal. The axial plane is an imaginary plane drawn parallel to the long dimension of the fold that attempts to divide the cross section

into equal halves. A symmetric fold has a vertical axial plane with limbs that dip away from each other at equal angles of dip (refer to Figure 2). The axial plane of an asymmetric fold is inclined with the limbs dipping away from each other, but at different angles of dip. Overturned folds are those whose limbs dip in the same direction. A recumbent fold is defined as one whose axial plane and limbs approach the horizontal. Except for the recumbent style, you will see examples of all of the fold types as the trip progresses.

The three major types of faults, *thrust* (or *reverse*), *normal*, and *strike-slip* are illustrated in Figure 5. Although faults are present throughout the Appalachians where their presence plays a major role in much of topography and structures you will see, their presence is not as evident at the surface as are the folds. Of the three types of faults, thrust faults dominate throughout the Appalachians, reflecting the compressional forces responsible for the formation of the mountains.

Joints are fractures in rocks along which there has been no appreciable movement. All rocks everywhere contain joints as will be evident in every rock outcrop exposed along the roadway.

Stratigraphy: Stratigraphy is the study of sedimentary rocks. A characteristic of all sedimentary rocks is that they are **bedded**. Initially, all sediments are laid down horizontally with the oldest layer being on the bottom with the overlying layers becoming progressively younger. Whether they now appear horizontal at the surface depends upon the kind of deformation they have been subjected to subsequent to their being converted into rock. If they are simply uplifted, the bedding of the rocks exposed at Earth's surface will still be horizontal. An excellent example are the rocks seen in the Grand Canyon that are the result of the vertical uplift of the Colorado Plateau over the past 20 million years. If, on the other hand, the rocks were subjected to compressive forces, as in the case of the Appalachians, the rocks will undergo folding.

Whether flat-lying or folded, the sedimentary rocks found in any area are summarized in a **stratigraphic column** which shows the vertical sequence of the rocks and their relative ages. The stratigraphic column for this trip is found in **Figure 6**. One of the most difficult aspects of any geology field trip is to keep track of the various rock units you will be seeing. I would suggest that you keep Figure 6 conveniently available so that you can readily refer to it to identify the stratigraphic location of the rocks you will see.

Bedding Attitude: Throughout most of this trip, the sedimentary rocks were uplifted with compressional deformation that resulted in the beds being folded and faulted. In the area of Morgantown and to the west, in a region called the Appalachian Low Plateau. The structures underlying the Low Plateau are symmetrical folds with amplitudes so small that the rocks appear horizontal. A few miles east of Morgantown, you will leave the Low Plateau and enter The Appalachian High Plateau. While the structures underlying the High Plateau are mostly symmetrical folds, the amplitudes of the folds are high enough that the structures form ridges. As you drive eastward across the High Plateau, the fold amplitudes and the angle of the bedding observed in the outcrops along the roadway changes. In one exposure, the bedding may be horizontal while in others, it may dip toward you (to the west) or away from you (to the east) Get into the habit of paying attention to the attitude of the bedding of the rocks along the roadway. In areas of folded rocks, the bedding will be horizontal as you cross the axis of an anticline or a syncline. As you approach the

Figure 6: Stratigraphic Column

Pennsylvanian System	
	Dunkard Group
	Monongahela Formation
	Conemaugh Formation
	Allegheny Formation
	Pottsville Formation
Mississippian System	
	Mauch Chunk Formation
	Greenbrier Formation
	Pocono Group
	Purslane sandstone
	Rockwell Formation
Devonian System	
	Hampshire Formation
	Chemung Formation
	Foreknobs Formation
	Brallier Formation
	Hamilton Group
	Mahatango Formation
	Harrell/Marcellus shale
	Needmore shale
	Oriskany sandstone
	Helderberg Formation
	Keyser formation
Silurian System	
	Tonoloway limestone
	Wills Creek Formation
	Bloomsburg Formation
	McKenzie Formation
	Clinton Group
	Rochester shale
	Keefer sandstone
	Rose Hill Formation
	Tuscarora sandstone
Ordovician System	
	Juniata Formation
	Martinsburg Formation
	Chambersburg Formation
	Chambersburg limestone
	New Market limestone
	Row Park limestone
	Beekmantown Group
	Pinesburg Station dolomite
	Rockdale Run Formation
	Stonehenge limestone
Cambrian System	
	Conococheaque limestone
	Elbrook limestone
	Waynesboro Formation
	Weverton Formation
pre-Cambrian System	
	Catoctin Formation

axis of an anticline, the bedding will dip *toward* you (Figure 7). Because all of the folds in the Appalachians trend NE-SW, this will be to the west. Note also that as you approach the axis of an anticline, the rocks become progressively *older*, that is you are going *down* stratigraphically. In any area of folded rocks, the oldest rocks will be exposed in the axis of a breached anticline or in the center of a water gap cutting through an anticlinal fold. Conversely, as you drive toward the axis of a syncline, the bedding will dip *away* from you (in this case to the east) and the rocks will become progressively younger; you will be going *up* stratigraphically. In an area of folded rocks, the youngest rocks will be found in the axial region of a syncline which, most often, will be a valley floor. Monitoring the attitude of the bedding as you drive is the best way for you to keep track of the folds that you will be crossing.

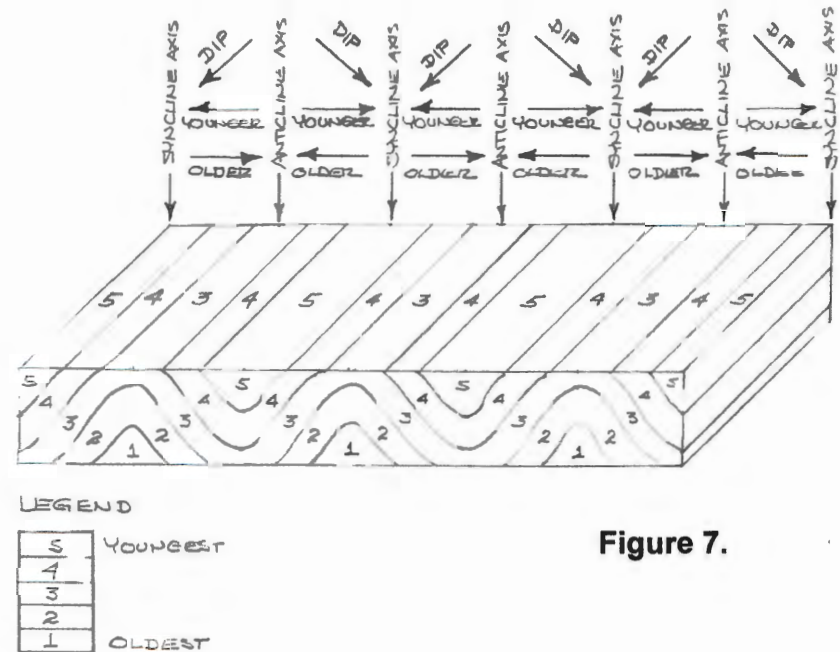


Figure 7.

Physiographic Provinces

Continents are subdivided into *physiographic provinces*. A physiographic province is defined as a region of which all parts are similar in geologic structure and climate and which has had a unified geomorphic history; a region whose pattern of landforms differ significantly from that of adjacent regions. The Appalachian region is divided into four physiographic provinces, which are from west to east: the *Appalachian Plateaus*, the *Valley and Ridge*, the *Blue Ridge*, and the *Piedmont* (Figure 8). While the trip will terminate in the Piedmont, many geologists do not consider the Piedmont Province as being part of the Appalachians.

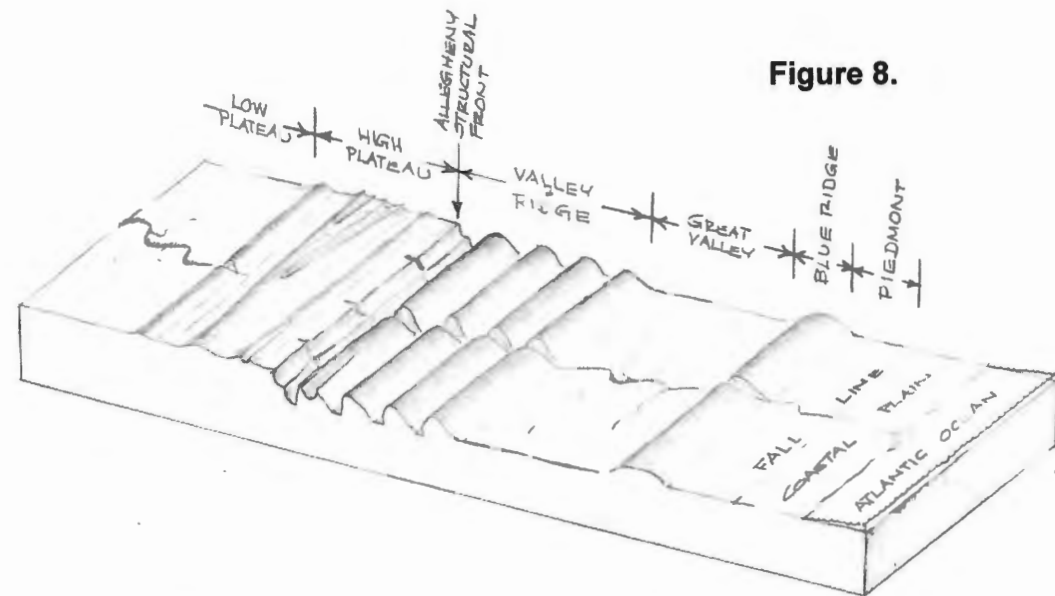


Figure 8.

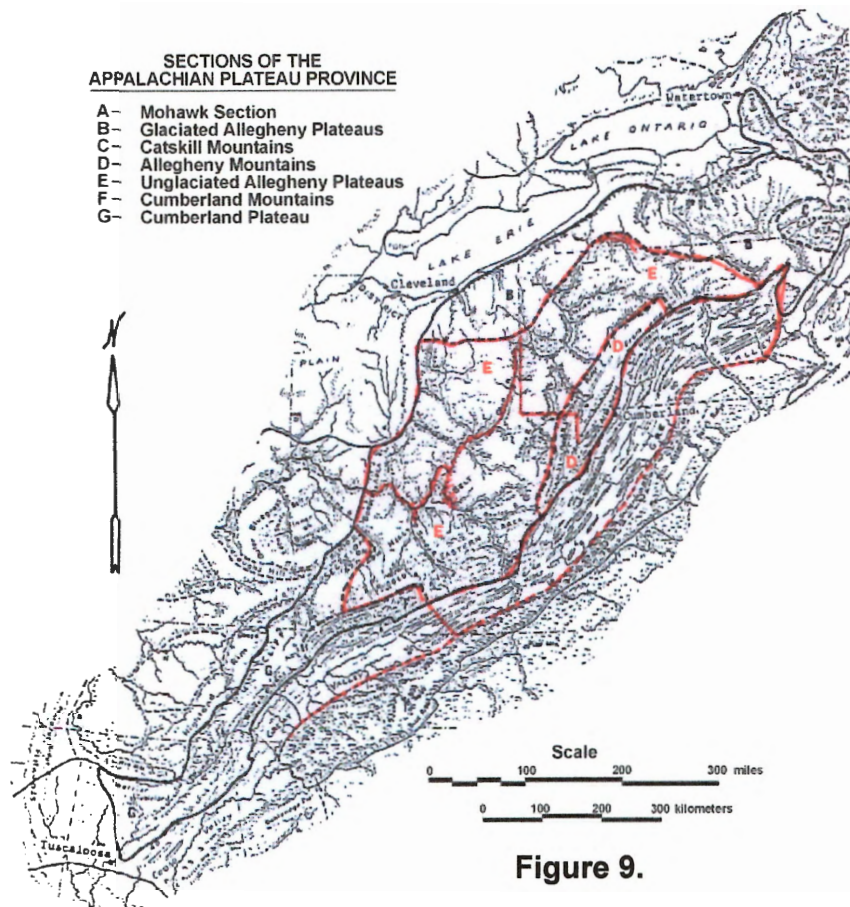


Figure 9.

because the dips on the limbs are so low (generally less than 2° or 3°) that the human eye cannot discern any dip on the beds. Although faults are probably present in the area, they are of very low displacement and are rarely seen at the surface.

Typical of areas underlain by essentially horizontal rocks, the dominant stream pattern throughout the Low Plateau is dendritic (Figure 10). In general, the streams have progressed to the mature stage of geomorphic development with most of the major streams having developed floodplains and meanders. Other characteristics of a mature

As the name implies, there are several Appalachian plateaus (Figure 9). The most northerly plateau, the Mohawk Plateau, extends northward from the Mohawk and Hudson rivers into New England. Next, the Glaciated Allegheny Plateau extends from the Mohawk Plateau southward to the maximum extent of the Pleistocene ice advance just south of the New York-Pennsylvanian border. The largest plateau, the Unglaciated Plateau, extending southward to Kentucky, is divided into an eastern Allegheny Mountain Section or High Plateau, a western Low Plateau, and the southernmost Cumberland Plateau. The terms, High and Low Plateau are my own means to designate the two basic regions within the Unglaciated Plateau.

The Valley and Ridge Province is subdivided into the eastern Great Valley Section and the western Appalachian Mountain Section.

Appalachian Low Plateau: The Appalachian Low Plateau is the westernmost of the Appalachian Plateaus Physiographic provinces. The Low Plateau is largely underlain by rocks of Pennsylvanian age (refer to stratigraphic column in Figure 6). Morgantown is located near the eastern edge of the Low Plateau. As previously mentioned, the rocks exposed in road cuts from Morgantown are deformed into very low amplitude symmetrical folds that appear as though they are perfectly horizontal. The reason why the bedding appears to be horizontal is

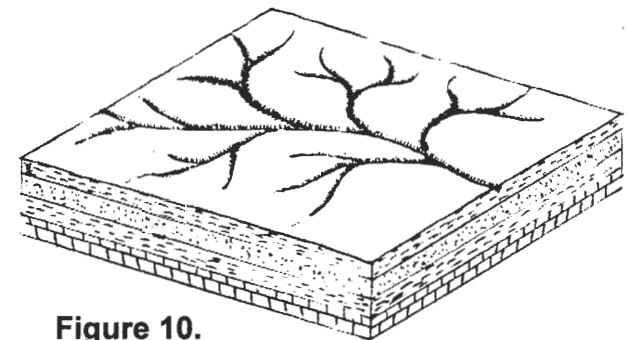


Figure 10.

topography include average distances from hilltops to valley floors, the *relief*, of a few hundred feet, with adjacent streams separated by rounded hills with relatively shallow slopes. The topography in the vicinity of Morgantown is typical of the province.

Most geologists consider the western limit for the Low Plateau to be located in central Ohio where glacial deposits and older Paleozoic rocks crop out. The easternmost limit of the Low Plateau and the beginning of the High Plateau is located just east of Morgantown at the western base of Chestnut Ridge. Chestnut Ridge is a dominant topographic feature that extends from just north of Uniontown, Pennsylvania, southwestward to Weston, West Virginia. The structure responsible for the ridge, Chestnut Ridge Anticline, is a symmetrical anticline. The NE-SW trend of Chestnut Ridge, and of all of the other major Appalachian structures, is the result of the great pressures that were applied from the southeast when the Allegheny Mountains were created about 250 million years ago. One can compare and contrast the topography of the high and low plateaus by referring to the Morgantown 7.5' topographic map available from the West Virginia Geologic and Economic Survey.

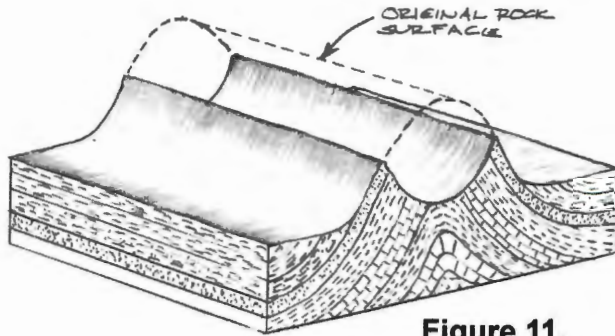


Figure 11.

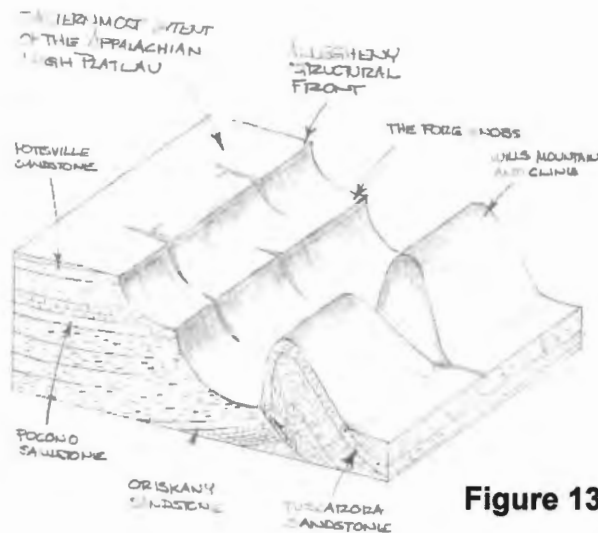


Figure 13.

The Alleghenian Mountain Section or Appalachian High Plateau: The Allegheny Mountain Section of the Unglaciaded Plateau, or Appalachian High Plateau, extends from Chestnut Ridge on the west to the Allegheny Structural Front on the east (refer to Figure 8). Rocks within the province range in age from Pennsylvanian to Devonian with the oldest rocks being exposed in the axial regions of breached anticlines (Figure 11). The dominant structures within the High Plateau are relatively high amplitude symmetrical folds with the increased amplitudes of the folds being due to the presence of thrust faults within the anticlinal cores that provided a vertical displacement of the rocks within the fold (Figure 12). The effect of the increased fold amplitudes is an increase in regional relief that results in a more rugged terrain than that seen throughout the Low Plateau to the west. Because of the increased relief of the High Plateau over that of the Low Plateau to the west, the Appalachian High Plateau has also been referred to as the Allegheny Mountains or the *open-fold* section of the Appalachian Plateaus. From central Pennsylvania to central West Virginia, the eastern-most edge of the Appalachian High Plateau is called the Allegheny Structural Front (Figure 13).

It is important to note that the highest elevations in the Appalachians are found just west of the Allegheny Structural Front and not, as one might expect, in

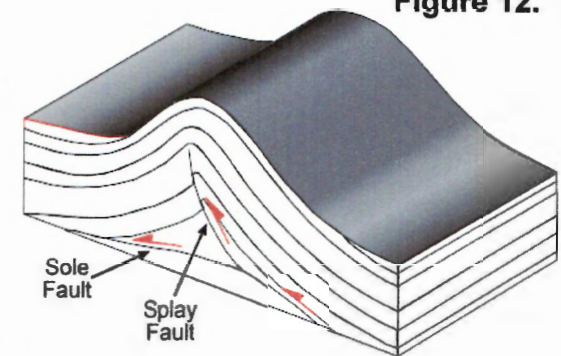


Figure 12.

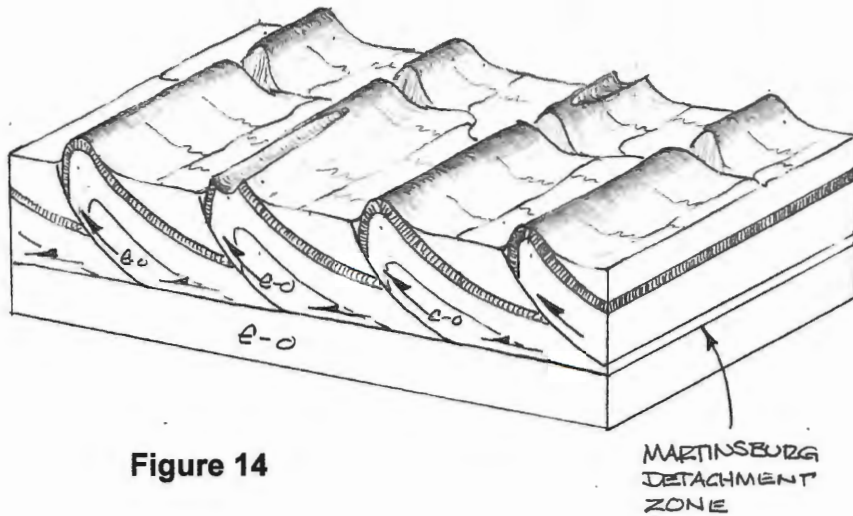


Figure 14

name reflects the dominance of northeast-southwest-trending parallel valleys and ridges within the province. For the most part, the ridges are high amplitude asymmetric to overturned folds, commonly broken on the western limb by high-angle thrust faults (Figure 14). The oversteepening of the folds to the west indicates an east to west direction of rock transport during the original mountain building episode. The wavelength of the folds in the Valley and Ridge (the distance between fold axes) is significantly less than the wavelength of the more open folds in the High Plateau to the west. Many of the anticlinal structures have been breached by erosion, exposing the oldest rocks of the region, the Ordovician, within anticlinal valleys. An excellent example of a valley that formed as the result of the breaching of an anticline that you may be familiar with is Germany Valley located in Pendleton County, West Virginia (Figure 15).

There are occasional synclinal ridges that you will observe along your route, the most well known being

the Appalachian Mountains to the east. The reason for this rather anomalous situation is due to the fact that the apex of the broad arch that was uplifted about 60 million years ago from the Mississippi River Valley to the Atlantic Ocean is located along the eastern edge of the Appalachian Plateaus.

An important economic aspect of the Appalachian Plateau are the mineable coal deposits that are located within its boundaries with the coal beds being contained within the Pennsylvanian rocks. One particular coal bed, the Pittsburgh coal, often referred to as the most valuable rock layer in the world, accounts for 25% of all the coal mined in West Virginia.

Appalachian Mountain Section: The Appalachian Mountain Section of the Valley and Ridge Physiographic Province extends from the Allegheny Structural Front to the Great Valley and constitutes what is commonly referred to as the Appalachian Mountains. The

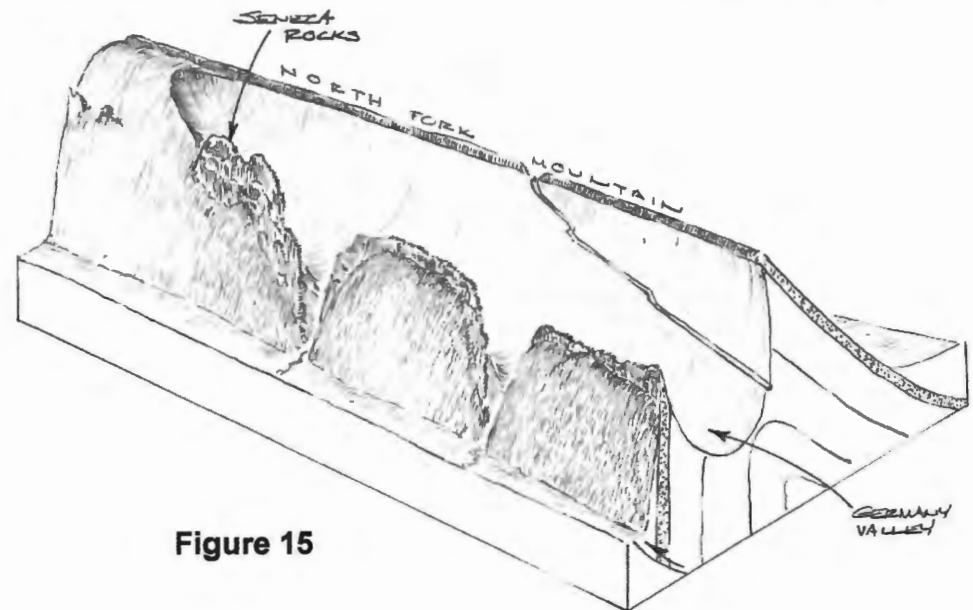


Figure 15

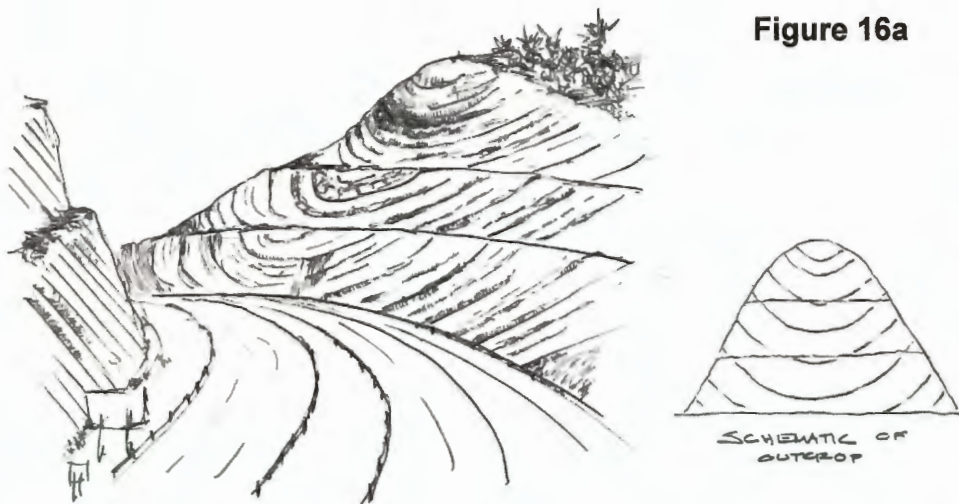
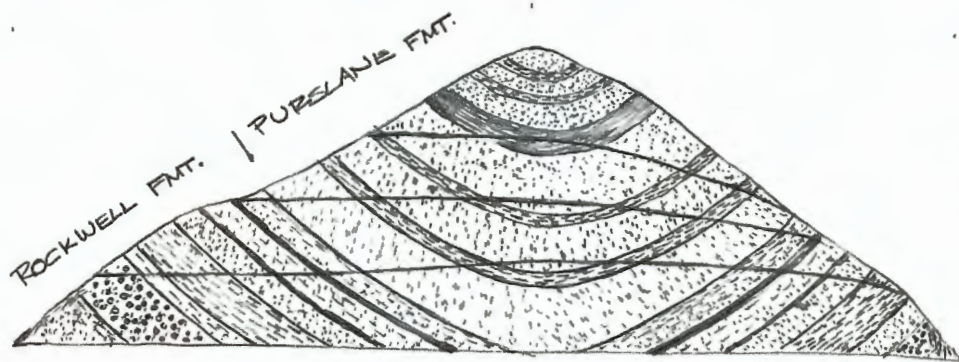
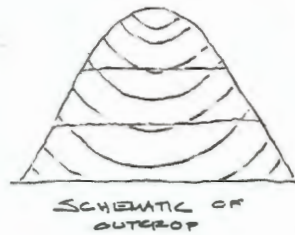


Figure 16a



LEGEND

	CONGLOMERATE
	SANDSTONE
	SILTSTONE
	SHALE
	COAL & BLACK SHALE

Figure 16b

Sideling Hill, Maryland. Synclinal ridges are formed as adjacent anticlines are breached with the subsequently valleys eventually being eroded below the elevation of the adjacent synclinal valleys, creating what geologists call "inverted topography" (Figure 16a and 16b). Eventually, the resistant rock layer becomes a tough caprock that remains high above the surrounding terrain as the rocks within the adjacent anticlinal structures are removed.

It is important to emphasize that the summits of all of the ridges within the Appalachian Mountains are lower in elevation than that of the easternmost edge of the Appalachian Plateau with the elevations of each more easterly ridge being generally lower than that to the west. This relationship results in the rather unique situation of one going down into the Appalachian Mountains when approached from the west.

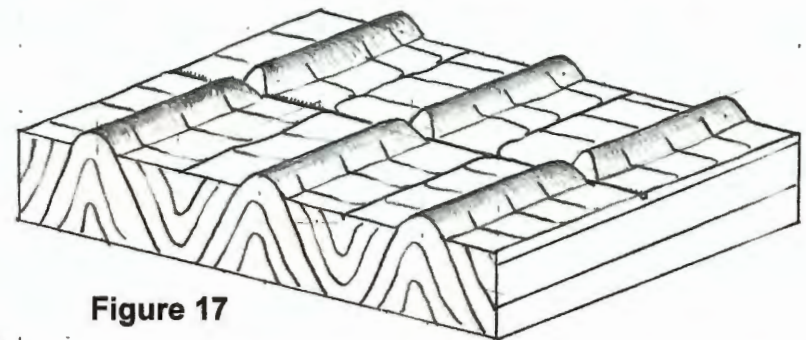


Figure 17

Because of the dominant northeast-southwest trending ridges and valleys, the stream pattern within the Valley and Ridge is *trellis* with the major streams cutting across the structures and tributaries draining the valleys (Figure 17). There is evidence that many, if not most, of the water gaps that cut across anticlinal structures follow vertical fault zones with the streams taking advantage of the zone of weakness.

The Great Valley Section: The Great Valley Section of the Valley and Ridge Province, commonly referred to as the Shenandoah Valley, extends eastward from the easternmost ridge of the Appalachian Mountain Section of the Valley and Ridge to the base of the Blue Ridge Mountains. Rocks within the valley are nearly all Cambrian and Ordovician limestones. Because of the water soluble nature of calcium carbonate, the rocks have been dissolved down to the mean level of the streams, resulting in a broad, flat valley. The few low ridges observed within the valley are in large part due to the occasional non-carbonate rock layer that is a bit more resistant to erosion. Although natural exposures of limestones are limited because of their solubility, numerous limestone rock outcrops can be seen in the fields. Typical of regions underlain by limestones, the soils are thin and are composed almost entirely of the insoluble materials, clay minerals and quartz, that were originally contained within the limestones. Also typical of areas underlain by limestones, the Great Valley shows extensive development of *karst topography* readily identified by the extensive number of sinkholes throughout the region (Figure 18). Because of their alkaline character, the soils are ideal for the growth of calcium-loving grasses which explains the widespread use of the land for the grazing of cattle. The red to orange color of the soil is typical of areas underlain

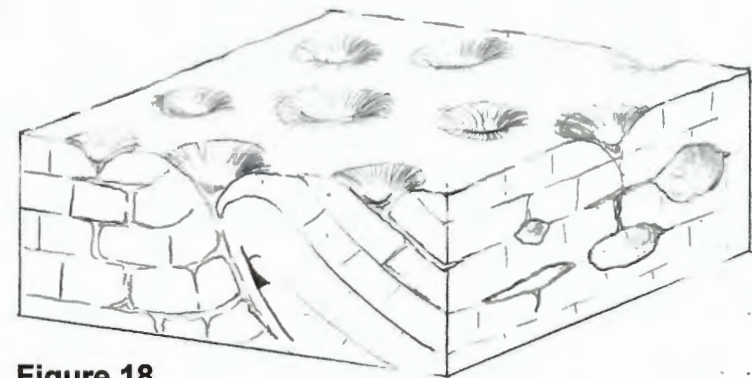









Figure 18

Table 1						
ORIENTATION	WEST			EAST		
FORCES	PASSIVE COMPRESSION ⇒			⇐ ACTIVE COMPRESSION		
ENERGY AVAILABILITY	MINIMAL			MAXIMUM		
GEOGRAPHIC REGION	APPALACHIAN PLATEAU		VALLEY & RIDGE PROVINCE		BLUE RIDGE MOUNTAINS	PIEDMONT
	LOW PLATEAU	HIGH PLATEAU	APPALACHIAN MOUNTAINS	GREAT VALLEY		
FOLD GEOMETRY	LOW AMPLITUDE SYMMETRICAL 	MEDIUM AMPLITUDE SYMMETRICAL 	HIGH AMPLITUDE ASSYMETRICAL 	HIGH AMPLITUDE ASSYMETRICAL 	RECUMBENT 	HIGHLY DEFORMED PLASTIC FLOW 
FAULTS (REVERSE) 	MAY BE PRESENT WITH VERY SMALL DISPLACEMENTS	DISPLACEMENTS: 1's to 10's OF FEET	DISPLACEMENTS: 10's to 100's OF FEET	DISPLACEMENTS: 100's to 1000's OF FEET	DISPLACEMENTS: 1000's OF FEET TO MILES	DISPLACEMENTS: ESTIMATED INTO 10's OF MILES
METAMORPHIC FACIES				LOW GRADE	MEDIUM GRADE	HIGH GRADE
IGNEOUS ACTIVITY					MAFIC TABULAR INTRUSIONS	FELSIC PLUTONS
	1	2	3	4	5	6

by limestone and is due to the fact that the insoluble materials released by the dissolution of the limestones are coated by combinations of red iron oxides, Fe_2O_3 , and yellow iron oxyhydroxides, $\text{FeO}(\text{OH})$.

Structurally, the valley is underlain by many northeast-southwest trending high-displacement thrust faults and highly deformed asymmetric and overturned folds which, because of the limited exposures, are not always easy to observe. As one approaches the easternmost portion of the valley, the rocks show evidence of low-level metamorphism, the result of being located closer to the original zone of deformation (Table 1).

The carbonate rocks in the Great Valley are often so pure that they were both quarried and deep-mined. Uses of the limestone products range from the flux-stone used in the iron and steel industry to remove silicate contaminants from blast furnaces, for the manufacture of cement, and to coat the walls of deep coal mines in order to reduce the amount of flammable coal dust in the atmosphere of the mine. Throughout much of the northern Appalachian coal basin, it is used to treat and inhibit the production of acid drainage.

The Blue Ridge Physiographic Province: The Blue Ridge Physiographic Province makes up the Blue Ridge Mountains. Structurally complex, the Blue Ridge consists of highly deformed and metamorphosed pre-Cambrian and Cambrian rocks that have been intruded by basaltic and rhyolitic magmas. The province is actually an eroded *anticlinorium*, the South Mountain Anticlinorium. An anticlinorium is a broad regional anticlinal structure composed of lesser folds. In the area of the trip, the province extends from South Mountain on the west to Catocin Mountain on the east with Middletown Valley located in between. Middletown Valley is floored by metabasalts and represents the core of the anticlinorium. To the south, erosion within the valley has exposed the billion-year old basement gneisses that underlie the structure. The basement rocks are of similar radiometric age beneath all of eastern North America! From central Ohio east to the Atlantic, the basement rocks are known as the Grenville Complex.

The Piedmont Physiographic Province: By definition, a piedmont is the plane or slope that exists at the base of a mountain. In this case, it is the sloping surface that extends eastward from the base of the Blue Ridge Mountains and disappears under the recent sediments of the Coastal Plain. The Piedmont Physiographic Province contains the most highly deformed rocks of the Appalachian region. Because of their highly deformed character, the rocks within the Piedmont succumb quite readily to chemical weathering. As a result, weathering over the past 100 million years has generated a thick *regolith* or *saprolite* that cover the rocks almost everywhere within the province. Below the thick layer of weathered material are amphibolites, schists, and ultramafic rocks known collectively as the Baltimore Complex. These rocks are interpreted to be oceanic crustal rocks that were shoved over the underlying younger rocks during a continent-continent collision that occurred 500 million years ago.

To the east, the Piedmont disappears under the Coastal Plain. The contact between the Piedmont and the Coastal Plain is referred to as the “Fall Line” because of the small waterfalls that commonly occur where streams flow from the more resistant rocks of the Piedmont onto the more easily eroded recent sediments of the Coastal Plain (refer to Figure 19). One of the best locations to view the Fall Line is at Great Falls Park just northwest of Washington, D.C. Here, the Potomac River has created a window to the Piedmont rocks which are otherwise covered by either saprolite or coastal plain sediments. Because bedrock within most of the Piedmont is rarely exposed, our trip will end at Frederick, Maryland, on the westernmost edge of the Piedmont.

The Coastal Plain Physiographic Province: Though not part of Appalachia, it is important to realize that the less consolidated materials of the coastal plain are, in reality, all the materials stripped from the Appalachians by erosion, brought east by rivers, and deposited along the eastern edge of the North American as part of its seaward extension, the continental shelf.

The Origin and Structure of the Appalachians

In order to get the most out of any field trip, it is essential to have a basic picture of the combined structure, stratigraphy, and erosional history of the area. Understanding how the structures within the area formed, although not essential, will add significantly to your overall understanding of the geology. In order to provide you with such an understanding, I must go beyond what you would learn in an introductory geology course. In the case of the Appalachians, it requires introducing you to a concept that describes the fate of sedimentary rocks that are involved in a major mountain building episode. The fact that you chose to go on this trip indicates that you are interested in understanding the geology of the Appalachians and would probably appreciate a more in-depth understanding of what you will see.

To illustrate how the structures formed, I have prepared two figures, **Figure 19** which is a block diagram depicting the present topography along with the various physiographic provinces and the subsurface structures and **Figure 20** (next page) that consists of five drawings that sequentially illustrate the evolution of the Appalachian structures.

The great mountains of the world were created by the collision of continents. A modern example, the Himalaya, are the result of the collision of India and Asia beginning about 45 million years ago, a collision that is not yet over as indicated by the frequency of earthquakes throughout the region combined with the fact that the Himalaya are still rising. The Himalaya, and all of the great mountains of the world including the Appalachians, are examples of *foldbelt mountains*, the name referring to the fact that a major portion of the mountain range

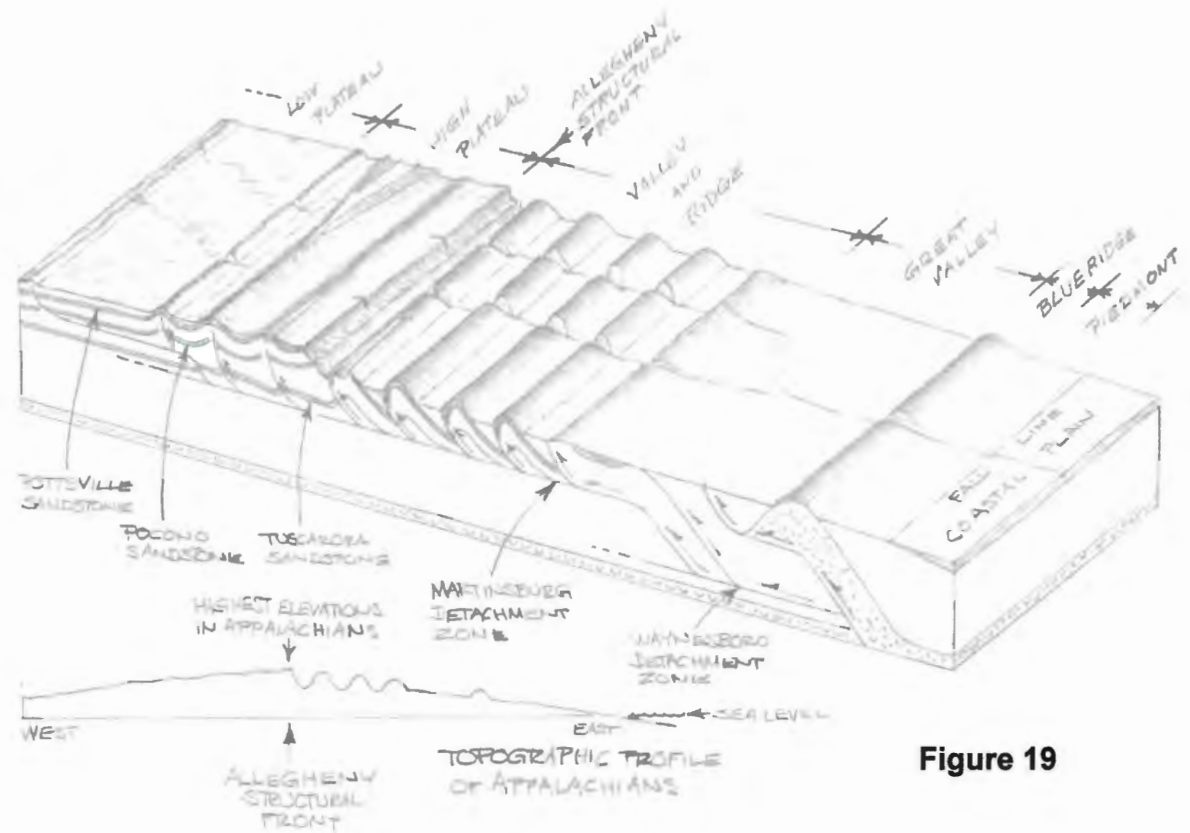


Figure 19

consists of folded (and faulted) sedimentary rocks. Another portion of all foldbelt mountains consists of an assemblage of igneous, volcanic, and metamorphic rocks that represents the immediate collision zone between the two continents with the foldbelt portion being farther away from the zone of collision.

For many years it was taught that the folds and faults that we see at the surface throughout Appalachia extended down to and included the granitic rocks of the underlying continental crust, the so-called “*basement*”. That somewhat simplistic picture changed in 1963 when data from deep seismic studies showed that not only was the basement *not* involved in the deformation, but that even the lower portion of the sedimentary rock section remained undeformed (refer to Figure 20). Compared to the massive thickness of the continental crust, the entire sedimentary layer overlying the basement is nothing more than a thin veneer. The data presented in the early 1960s showed that most of the deformation observed within the Appalachians was limited to the upper portion of the total thickness of sedimentary rock while the lower section of sediments and the underlying basement remained relatively undeformed. This observation gave rise to the new hypothesis being dubbed “*thin-skinned tectonics*”.

According to the hypothesis, the forces generated by the collision caused the upper sedimentary rocks to break away, or *detach*, from the underlying sediments along the bedding of certain weak rock layers forming a *zone of detachment*. It should come as no surprise to find that detachment zones form primarily within shale formations, the weakest of all the sedimentary rocks. In addition to the inherent weakness of shale, some shale formations contained materials such as organic material, and in one case salt, that serve to “grease the slide” and promote lateral movement. Within the Appalachians, there are four rock formations that serve as zones of detachment (refer to Figure 6). From oldest to youngest, these are the Cambrian Waynesboro Formation, the Ordovician Martinsburg Formation, the Silurian Salina Formation, and the Devonian Harrel-Marcellus Formation.

Once detached from the underlying rocks, the layer of sedimentary rocks above the zone of detachment began to move in the direction of the applied forces which, in the case of the Appalachia, is westward. In order to make room for these laterally-moving masses of rocks, thrust faults *ramp* the rocks upward from the zone of detachment, stack the rocks vertically, and generate folds. All the while, the rocks below the zone of detachment remain undeformed. The process can be visualized by considering the removal of a layer of snow from a sidewalk using a plow-type snow shovel. At first, the snow can be pushed ahead with the surface of the sidewalk representing the detachment zone. In time, however, as the snow accumulates in the shovel and the snow ahead of the shovel becomes compacted, continued forward movement becomes increasingly difficult. At that point, you “ramp” the shovel upward to get rid of the accumulated snow, allowing the process to continue.

The result of the continent-continent collision that formed Pangea is schematically illustrated in Figure 20, Drawings ‘b’ through ‘e’. The initial collision resulted in the development of a major thrust fault that originated within the basement that drove the pre-Cambrian crystalline rocks (granitic rocks and various volcanics) upward along with the overlying Cambro-Ordovician rocks. It is important to know that the Cambro-Ordovician rocks are dominantly carbonates (limestones and dolomites) (refer to the Stratigraphic Column in Figure 6). Upon arriving at the level of the Ordovician Martinsburg Formation, the compressive forces created a zone of detachment within the shale-rich Martinsburg Formation along which the rocks moved laterally. Eventually, as the resistance to further forward motion increased, another thrust fault formed that ramped the pre-Cambrian and Cambro-Ordovician rocks upward. The drawing shows only Cambro-Ordovician rocks being displaced along with the pre-Cambrian basement when, in fact, Silurian and younger aged rocks could have been (no doubt

were) involved. Because all of the rocks younger than the Cambro-Ordovician age were subsequently removed by erosion, their presence is not indicated in the drawings. The pre-Cambrian and some of the basal Cambrian rocks that were involved in the initial thrusting are now exposed in the Blue Ridge Mountains with the Cambro-Ordovician rocks shown to the east in drawing "b" now being preserved as highly metamorphosed rocks within the Piedmont Province. The Cambro-Ordovician carbonate rocks shown to the west of the pre-Cambrian are now exposed in the eastern portion of the Great Valley. Note that the drawing indicates that while this major pre-Cambrian displacement was occurring, a new detachment zone was forming within the shaley Cambrian Waynesboro Formation along with an incipient ramp leading upwards to the Ordovician Martinsburg Formation.

Drawing "c" shows that the incipient detachment and ramp illustrated in Drawing "b" becomes a full-scale detachment zone with the Cambro-Ordovician rocks being thrust over the underlying Cambro-Ordovician rocks and driven westward along the Martinsburg zone of detachment. In time, the rocks leave the Martinsburg detachment zone and are ramped upward. The Cambro-Ordovician carbonate rocks involved in these detachments are now exposed in the western portion of the Great Valley. Note that Drawing "c" also indicates the westward extension of the Martinsburg zone of detachment with incipient thrusts ramping upward into the younger rocks.

Drawing "d" illustrates the ramping of the Cambro-Ordovician rocks from the Waynesboro detachment zone up to the Martinsburg zone of detachment. As the rocks move westward along the zone of detachment, several thrust faults break upward to generate the folds now seen in the Valley and Ridge. Note that Silurian and younger rocks are indicated above the Cambro-Ordovician rocks. Erosion in this area will eventually remove all rocks younger than the Devonian Harrel-Marcellus Formation which will floor the synclinal valleys. As the rocks were removed from the axial regions of the anticlines, erosion eventually reached the stratigraphic level of the Tuscarora sandstone. At this point, the extreme resistance of the Tuscarora sandstone slowed the erosion process, resulting in the formation of most of the ridges of the Appalachian Mountain Section of the Valley and Ridge Province. The ridges of the Appalachian Mountain Section are said to be *capped* by the Tuscarora sandstone. Along the summits of some of the highest ridges, the anticlines were breached as erosion cut through the resistant Tuscarora sandstone, exposing the weaker rocks below. In time, erosion formed anticlinal valleys, an excellent example of which is Germany Valley ([refer to Figure 15](#)). In addition, erosion by antecedent streams such as the Potomac successfully carved water gaps through the Tuscarora-capped ridges to allow the streams to continue their passage to the Atlantic Ocean. To the west of the Valley and Ridge, Drawing "d" shows the Martinsburg detachment continuing and faults ramping up to the next higher zone of weakness, the Salina Group. As the name implies, the Salina Group of rocks throughout the Appalachians contains salt. Being very plastic, the salt within the rocks resulting in the formation of the zone of detachment.

The last drawing illustrates the final stage of the Appalachian tectonics as thrusts ramp upward from the Martinsburg Formation and from the Salina Group to form the structures of the High Plateau section of the Unglaciaded Appalachian Plateau. Because the amount of available energy decreases westward, the displacement of the faults and the amplitudes of the folds formed within the High Plateau were significantly less than those that characterize the Appalachian Mountains to the east. Even within the Unglaciaded Plateau, the marked westward decline in available deformational energy resulted in the formation of High and Low Plateaus. Under the High Plateau, there was sufficient fault displacements to create anticlines with amplitudes large enough to generate significant topographic highs. You will encounter the westernmost of these anticlines, Chestnut Ridge Anticline, shortly after leaving Morgantown and will cross all of them by the time you reach the easternmost edge of the Appalachian High Plateau, the Allegheny Structural Front.

There is no positive evidence for the existence of faults under the Low Plateau. If present, they are of very small displacement. As a result, the amplitudes of folds within the Low Plateau are so low that the rocks appear perfectly horizontal, as illustrated by the rocks seen in road cuts in the vicinity of Morgantown and to the west. There is also some evidence from well records that a zone of detachment may be present within the Devonian Harrel-Marcellus Formation. Because there is little surface effect, a Harrel-Marcellus zone of detachment is not shown in Drawing 'e'. The westernmost limit of detachment is where a thrust fault ramps from the Salina zone of detachment to the surface at the Burning Springs Anticline in western West Virginia. A summary of the structural relationships that exist within the Appalachians can be found in Table 1.

Road Log

A cross section from Stop #1 to the Genstar quarry at the western margin of the Piedmont Province is illustrated in Figure 21 (next page). You should keep this cross section at hand throughout the trip to help you locate yourself structurally. Because of the scale of the cross section, none of the small-scale folds you will see along the way can be shown on the drawing. The large folds, however, are indicated and should help you understand the attitude of the rocks along the course of the trip.

Unfortunately, state law prohibits non-emergency stopping along the interstate system. Along the initial West Virginia portion of the trip, I will indicate a few stops where you will be able to pull completely off the road and berm. Should you want to stop and get a better view of the land about you, take advantage of the exits, but **do not stop** along the main roadway.



Figure 22

Two figures that you should always have at hand as you drive are Figure 6 which contains the stratigraphic column and Figure 21 which is a cross section of the rocks you will be crossing. The stratigraphic column lists all of the rock units by age and by name and indicates the kind of rock that constitutes the unit while the cross section will allow you to determine what structure you are crossing at any point along the way.

0.0 mile: Stop #1: Exit #7, junction of I-68 and WV Rt.857. You will begin your trip near the easternmost edge of the Appalachian Low Plateau. The rocks at the westbound exit include, from top to bottom, the Lower Sewickley sandstone, the thin (1.5') Redstone coal horizon, the Upper Pittsburgh sandstone, and the Pittsburgh coal at the base (Figure 22). Dominant crossbeds and scalloped bottoms of the sandstone beds indicate them to be fluvial (stream) channel sandstones. The Pittsburgh coal is the most important single coal bed

mined in the area, accounting for 25% of the entire coal production of West Virginia. The Pittsburgh coal was removed by surface operations at the southwestern corner of the intersection and it was deep-mined beneath the Glenmark Mall and the Morgantown Airport.

From this point westward, the topography is typical of the Appalachian Low Plateau being characterized by relatively low relief (the average distance between hill tops and valley floors), broad stream valleys occupied by meandering streams, low hill slopes, and rounded hill tops. Although the rocks throughout the Appalachian Low Plateau are folded, the amplitudes of the folds are so low relative to their widths that the rocks appear to be horizontal.

Set your odometer to zero as you pull onto the on-ramp to I-68 East.

2.2 mi. As you approach the western end of the Cheat Lake bridge, you are going down section as you drop into the valley of the Cheat River. Downstream, the river is dammed by a hydroelectric facility that produced Cheat Lake. Originally called Lake Lynn after the CEO of the power company at the time the lake was formed behind the dam, the locals always referred to it as Cheat Lake. After several decades, the state officially changed the name of the lake from Lake Lynn to Cheat Lake, indicating the power of public opinion.

The large outcrop that appears to your left just before reaching the bridge contains approximately 260 feet of rock from the Connelville sandstone at the top to the shale below the thin Harlem coal at the bottom. Note that typical of the rocks in the Low Plateau, the rock layers appear horizontal. The skyline before you to the east is the crest of Chestnut Ridge Anticline, the westernmost structure of the Appalachian High Plateau.

As you cross the Cheat Lake bridge, to your right is an excellent view of the V-shaped valley cut by the Cheat River through the Chestnut Ridge Anticline.

3.2 - 3.3 mi. The sandstone that appears along the left side of the roadway after you have crossed the Cheat Lake bridge and passed Exit 10 is the Buffalo sandstone. Note once again the presence of cross beds indicating its fluvial origin.

4.0 - 4.1 mi. As you begin the ascent of the west flank of Chestnut Ridge, a broad grassy area will appear along the roadway to the right that will allow you to pull completely off the roadway and berm. This will be **Stop #2**. The rocks exposed at Stop #2 include a section from the Buffalo sandstone at the top to the Upper Freeport sandstone at the bottom with the Mahoning sandstone in the middle (**Figure 23**, next page). Most conspicuous is the relatively thick (13') Upper Freeport coal located below the Mahoning sandstone. The Upper Freeport is a major coal mined in the northern Appalachian Coal Basin. Unfortunately, because of its high sulfur content, it is also responsible for many of the environmental problems that have plagued the coal industry in this part of West Virginia, the most serious of which is acid mine drainage (AMD). Another thinner coal, the Brush Creek coal, can be seen at the top of the section below the Buffalo sandstone.

There are four packages of rocks within the outcrop that represent four different depositional environments. The oldest rocks (labeled #1), include the thick-bedded Upper Freeport sandstone and the overlying thin Brush Creek coals, represent a peat swamp environment. At the time these deposits were laid down, the area around what is now Morgantown was a vast coastal plane with the shoreline far to the northwest. Extensive planar swamps developed across the coastal plane. During the times when coal-forming peats were accumulating, the swamps

were far enough removed from the coastline that the waters within the swamp were totally dominated by the fresh water provided by surface runoff and groundwater and were unaffected by any marine waters. This is an important point in that the rate of organic decomposition is primarily determined by the pH of the surrounding water. Any introduction of seawater would have increased the pH of the swamp water to the point that the rate of decomposition of the plant debris would have been so high that there would not have been sufficient organic material preserved to produce a coal-forming peat. Modern studies have shown that in order for peat to accumulate in sufficient quantity to be precursor to a coal bed, the pH of the water in the swamp must be maintained below 2.5 to 3. Above pH3, the rate of organic degradation increases rapidly. In fact, the black shales that enclose the coals represent periods of time when the water pH within the swamp *was* in excess of 3, perhaps due to tidal incursion of seawater during periods of high sea levels.

The rock package labeled #2 consists of overbank materials that were deposited during flood and as the result of the breaching of the levees that bordered the rivers. Such breakouts, called **crevasse splays**, resulted in enormous volumes of detrital material being flushed into the surrounding area, destroying the swamps and burying the accumulated peat. As additional stream-deposited sediments accumulated, processes began within the buried peat that would eventually convert it to coal.

Rock package #3 consists of channel sandstones. These sandstones represent sand that accumulated in the channels of streams that now began to sweep back and forth across the coastal area, eroding much of the more fine-grained underlying overbank deposits in the process. The rock body can be clearly indicated by the scalloped bottom which represents the base of the channel as it cut into the soft sediments below. An excellent example of such scouring is the channel exposed in the center of the outcrop. Today, this package of sandstone is called the Mahoning sandstone.

The Buffalo sandstone is the final package of rocks exposed at the top of the outcrop (#4) and consists of point bar deposits laid down by the meandering streams that continued to criss-cross the area. Point-bar deposits are easily recognized by the well-developed cross bedding that dip in the direction in which the stream was meandering. This is the same sandstone that was exposed at the Cheat Lake exit ramp, which gives you an idea of the angle of dip of the western limb of the Chestnut Ridge anticline.

As you leave Stop #2, you will continue up the western limb of the Chestnut Ridge Anticline. The slope of the roadway is approximately the angle of dip of the western limb of the Chestnut Ridge Anticline. Note that the dip of the rocks on the western limb of the anticline are significantly higher than the limbs on the folds found anywhere within the Low Plateau to the west. The most conspicuous rocks along the roadway are the fluvial sandstones ranging from the Lower Freeport sandstone down section to the Lower Connequenessing sandstone. The most obvious features of these sandstones are the cross beds and the scalloped bed bottoms, all characteristic of the type of stream-deposited sandstone bodies you observed at Stop #2.

4.5 mi. Along your right, you will be able to observe several excellent examples of the mass wasting process called rock fall. Sandstone bodies underlain by easily weathered shales are particularly prone to this type of failure. Decades of freeze/thaw cycles and subsequent ice wedging pried joints open, eventually resulting in the detachment of large rocks from the original bed. As erosion of the soft underlying shales removes support from below, the rocks eventually succumb to gravity and fall to the base of the outcrop.

7.4 mi. The Coopers Rock Off-Ramp. The rock exposed along the off-ramp to Cooper's Rock is the Lower Connequenessing sandstone. If you feel you can spare the time, you can exit I-68, turn right and proceed to the overlook at Coopers Rock to experience a classic V-shaped youthful stream valley. As the region was uplifted and the Chestnut Ridge Anticline rose across the west-flowing Cheat River, the river successfully carved its channel through the rising structure, became *antecedent* to the structure, and was thereby able to continue its course to the Gulf of Mexico via the Monongahela, Ohio, and Mississippi rivers. Stream erosion has exposed the Mississippian Greenbrier limestone in the core of the water gap. Research performed in the valley suggests that the Cheat River has been lowering its channel at a rate of 58 meters per million years.

8.2 mi. The Crest of Chestnut Ridge. The rocks at this point are the Homewood sandstone underlain by coal and coally shale and the uppermost portion of the Upper Connequenessing sandstone. The vista to the east gives an excellent view of the Appalachian High Plateau. From this vantage point, one can see the marked difference in the topography as compared to the more gently rolling topography of the Low Plateau from which you have just departed. To the east, the increased relief between the ridges and valleys is apparent. The distant skyline is Meadow Mountain, about 25 miles east of your present location.

At this point, your elevation is approximately 1,900 feet (579 m); 1,000 feet (305 m) higher than at Morgantown. It is interesting to note that in the hot, muggy summers that one often experiences in Morgantown, the temperatures at crest of Chestnut Ridge average about 10 degrees cooler; a result of the rule of thumb that the temperature of the atmosphere decreases about 1 degree per 100 foot rise in elevation as a result of adiabatic cooling.

Note as you drive eastward toward the WV-MD state line how the increased amplitudes of the folds has affected both the topographic relief and the dips one observes in the rock layers exposed along the road. In the 16 miles between the crest of Chestnut Ridge and the WV-MD state line, the rocks underlying the region ranged from the Mahoning sandstone to the Homewood sandstone.

15.6 mi. Bruceton Mills Exit

20.9 mi. Note the impact of the acid mine drainage (AMD) generated by the weathering of the high sulfur coals and coal associated rocks along the median. The neutralization of the acid waters results in the precipitation of the orange-colored $\text{FeO}(\text{OH})$ that is responsible for the "yellowboy" coating many of the streams in the northern Appalachian coal field. Upon exposure to the atmosphere and subsequent dehydration, the yellowboy turns red as the hydrated iron oxide is converted to hematite, Fe_2O_3 .

22.0 mi. Another excellent example of the impact of acidic coal-associated rocks on the survival of vegetation can be seen along the right-hand lane. Many of the black shales associated with the coals have higher sulfur contents than the coals themselves and therefore have high acid-producing potentials. At this point, the outcrop is dominated by black shales that produce surface conditions that are too acid for any plant community to survive.

24.7 mi. The WV-MD State Line. The rocks exposed at the state line are largely the Mahoning and Upper Freeport sandstones separated by a thin outcrop of the Upper Freeport coal and the Bolivar underclay. From this point, I-68 descends into the valley of the Youghiogheny River. The rocks along the roadway are largely covered, but a few sporadic outcrops of the sandstones and shales of the Glenshaw Formation can be seen.

26.8 mi. MD 42 overpass

28.7 mi. Youghiogheny River bridge. An interesting bit of trivia is the fact that the Youghiogheny River is Maryland's only north-flowing river. It flows northward into Pennsylvania where it enters the Monongahela River which, in turn, joins the Allegheny River at "The Point" at Pittsburgh to form the Ohio River.

29.4 mi. Bear Creek

38.4 mi. Crest of Keyzers Ridge and US 219 overpass. About 60 feet of fluvial sandstones of the Mississippian Purslane Formation and the underlying Rockwell Formation of Devonian-Mississippian age are exposed in the extensive exposures created by the I-68/US 219 interchange. The nearly flat lie of the rocks at Keyzers Ridge is due to the fact that you have just passed the crest of the Accident Anticline. Your elevation at this point is 2880 feet (887 m).

40.3 mi. Crest of Negro Mountain. Excellent exposures of the sandstones of the Pottsville Formation can be seen. It is important to note that sandstones of the Pottsville Formation are the major ridge-formers throughout the Appalachian High Plateau. Negro Mountain is the western edge of the Casselman coal basin and syncline. The elevation at this point is 2240 feet (690 m). In Pennsylvania, the summit of Negro Mountain is the state's highest point. The axis of the Casselman Syncline will be crossed a few miles east of Negro Mountain.

41.5 mi. Amish Road Overpass. If you are interested, you might make a slight detour at this point and exit to Grantsville where there are several points of interest. Proceed east on Rt.40 and visit the Old Stone Bridge, a span on the National Road that was built in 1813 and was in use until 1933. The high arch of the span was to accommodate the C&O canal that was originally to come through the site before the advent of the steam locomotive dashed the dreams of the canal builders. Locally, this site is known as "The Narrows". The reason why the National Road, Rt. 40, and most recently I-68, are all clustered adjacent to each other at this point is because this is the best place to cross the Allegheny Mountains. It might also be pointed out for the gourmands amongst you that the small town of Grantsville is home to two well-known restaurants, Penn Alps and the Casselman Inn. Now back to I-68.

43.7 mi. MD 495 overpass. Although most of the road cuts are covered in this segment of the trip, glimpses of the Glenshaw Formation and the Bakerstown coal bed can occasionally be seen.

47.7 mi. Crest of Meadow Mountain. Road cuts on both sides of the roadway expose sandstones and shales of the Pottsville Formation. A gentle dip can be seen to the west into the synclinal axis. The elevation at this point is 2780 feet (856 m). Meadow Mountain is the western limb of the breached Deer Park Anticline, a major anticlinal structure within the High Plateau. We will see eastern limb of the structure at Big Savage Mountain. A cross section showing the structure from Meadow Mountain to Big Savage Mountain is illustrated in **Figure 24**.

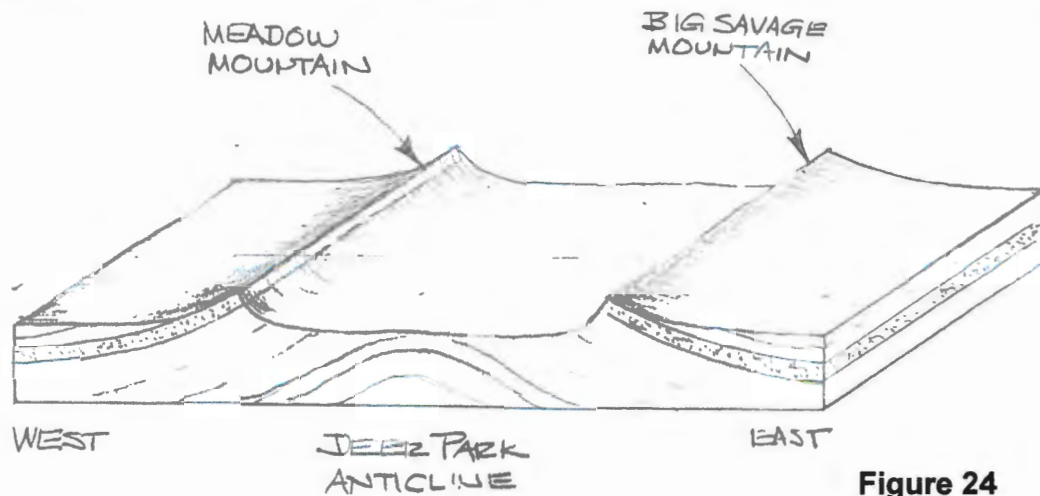


Figure 24

48.1 mi. Lower New Germany Road overpass. South of the highway is Wolf Swamp, one of several high elevation bogs and swamps in Garrett County, Maryland. These swamps date back over 15,000 years to the close of the last glacial episode when the area was much colder and was covered with periglacial tundra. Today, these wetlands contain a complex of northern plants and animals that are adapted to the colder climate.

50.4 mi. Green Lantern Road overpass. As indicated by the road sign, this is the **Eastern Continental Divide**. To the west of this point, all streams flow into the Gulf of Mexico while all those to the east flow into the Atlantic Ocean. The reason

why the divide is so far west of the eastern edge of the Appalachian Plateau is because eastward-flowing streams have incised their channels by headward erosion into the eastern edge of the Plateau. This is another example of a breached anticline. The continental divide represents the most westerly headwaters of east-flowing streams. Approaching the Green Lantern Road overpass, the westward-dipping red sandstones and shales of the Hampshire Formation are exposed to the left. The elevation at this point is 2610 feet (803 m).

52.4 mi. Frostburg Road Overpass.

53.7 mi. MD 546 overpass. If you are more attuned to tree types, you may have observed spruce trees along the roadway over the last three or so miles. I am told by botanist friends that normally, spruce trees are limited to the more northerly conifer forests. This portion of the Appalachian Plateau in Maryland is the only place in the state with a climate severe enough to be capable of supporting these more northerly tree types.

54.8 mi. Crest of Big Savage Mountain. After traveling eastward from the MD 546 overpass, you crossed the axis of the Deer Park Anticline with the upper Foreknobs Formation exposed at its center (refer to Figure 24). Extensive exposures of sandstones of the Pottsville Formation interbedded with black shales and thin coal beds can be seen at the crest of Big Savage Mountain.

57.2 mi. Midlothian Road. As you leave Big Savage Mountain and travel toward the axis of Georges Creek Syncline, the rocks become progressively younger. The black shale talus seen along the road to the right is from the Casselman Formation of the Conemaugh Group. Further on, glimpses of the coals and black shales of the Monongahela Group can be seen. To the north of the highway is a surface mine in the Pittsburgh coal, the same coal bed you saw as you began this trip at the Pierpont exit (mile 0.0). The sandstones and shales exposed at Midlothian Road belong to the Monongahela Group. The Monongahela Group contains most of the economically valuable coals mined in the northern Appalachian Coal Basin.

58.9 mi. Junction of I 68 and MD 36. At this point you are in the axis of the Georges Creek Syncline and surrounded by the youngest rocks you will observe in the trip, the Dunkard Group. Some argument still remains as to the age of the Dunkard Group. Some geologists consider it to be basal Permian while most workers in the area consider it to be uppermost Pennsylvanian. Pollen grains could have been used to determine the age of the rocks but, during mountain building, the rocks were “cooked” and the pollen grains were destroyed. The Georges Creek Syncline contains the coals of the most easterly of Maryland’s five coal basins.

61.1 mi. The Allegheny Structural Front. You have reached the easternmost edge of the Appalachian Plateau and the most dramatic change in geology anywhere in the Appalachians (Figure 25). Since leaving Morgantown, you have constantly gained in elevation. The highest elevations throughout the Appalachian region are located along the Allegheny Structural Front due to the fact that it represents the maximum elevation of the broad arch that uplifted the eastern portion of the continent beginning 60

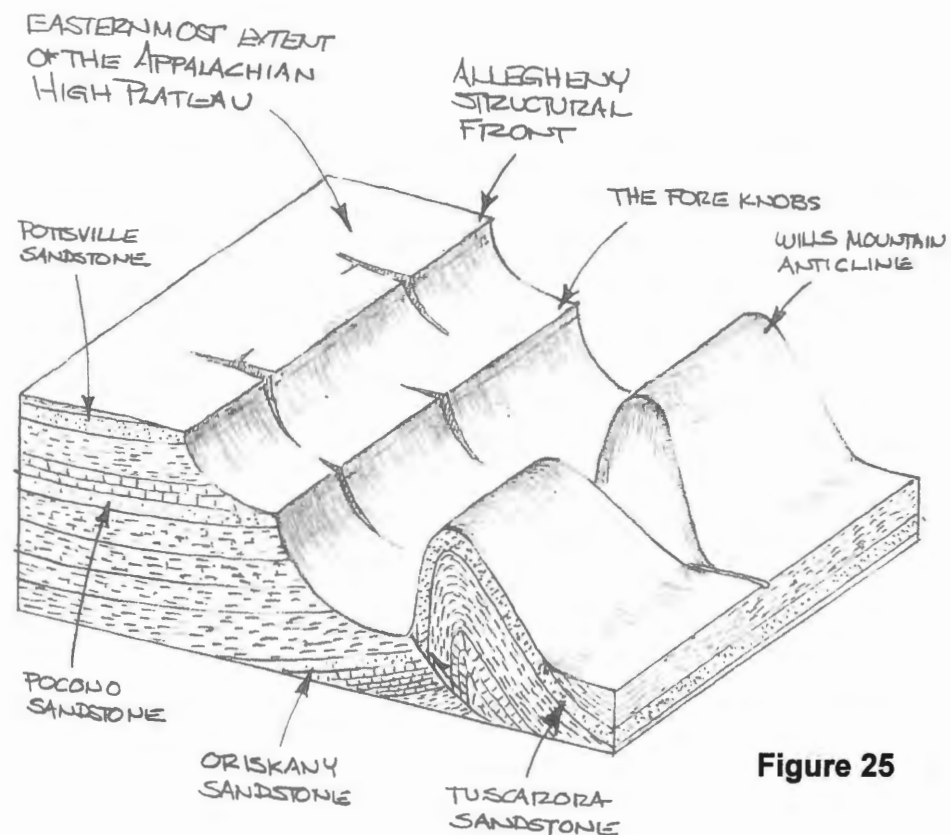


Figure 25

million years ago. In West Virginia, for example, the highest elevation, at 4,862 feet (1,482 m) is Spruce Knob, located right on the very edge of the Front. The highest point in Maryland is Backbone Mountain at an elevation of 3,360 feet (1,024 m).

Behind you stretches the Appalachian Plateau; before you lies the Appalachian Mountains Section of the Valley and Ridge Physiographic Province. While most of the rocks you observed west of the Allegheny Structural Front were of continental origin, from this point on, the rocks are dominantly marine. The rocks at the edge of the Appalachian Plateau are the massive sandstones of the Pottsville Formation. At this point you will begin the long descent down into the Valley and Ridge Province. As you make your descent, you will pass through rocks of the Mauch Chunk, Greenbrier, and Purslane Formations. Most of these rocks are easily weathered and are not well exposed. Below, however, you will encounter the gray-green laminated sandstones of the Rockwell Formation interbedded with red, greenish, or gray shales. As you approach the base of the descent, you will encounter redbeds of the Hampshire Formation and at the bottom, the largely concealed sandstones and shales of the Foreknob Formation. It is interesting to note that you *descend* from the Appalachian Plateau into the Valley and Ridge, that is, you went *down* into the mountains, not up as is most often the case. Every ridge in the Appalachian Mountains is lower in elevation than the edge of the Appalachian Plateau. Another interesting point is that as you descended from the edge of the Plateau, you traversed 100 million years of Earth history from the latest Pennsylvanian back to the Devonian.

64.0 mi. La Vale Exit. At this point we will take another short side-trip to allow you to get the true feeling of the anticlinal ridges that typify the Appalachian Mountains, most of which are highly asymmetric to overturned to the west. Leave I-68 at the La Vale exit and turn left at the intersection with MD68. Continue to Rt 40 and turn right. In about 4 miles you will turn into the Narrows, the water gap cut through Wills Mountain Anticline, the westernmost structure of the Valley and Ridge Province. As you drive into the Narrows, note the vertical outcrop to your left. This is the Tuscarora Sandstone on the western limb of the Wills Mountain Anticline. The Tuscarora Sandstone, a quartzose sandstone (quartz grains cemented by quartz), is the major ridge-former throughout the Appalachian Mountains. As you proceed, note that the Tuscarora arches up and over the valley wall and begins to descend, much more gently to the east on the eastern limb of the highly asymmetric anticlinal structure. The red rocks you see below the Tuscarora are the shales and sandstones of the basal-Silurian Juniata Formation. You may want to stop for a few minutes on the eastern side of the Narrows to get a better feeling for the structure.

After leaving the Narrows, return to La Vale on Rt.40. Continue beyond the intersection with MD68 a mile or so and turn right into the Lowe's parking lot where you can view not only an exposure of the Devonian Brallier Formation but also an excellent view of the Narrows water gap. Return to I-68.

65.2 mi. Crest of Haystack Mountain. After returning to I-68, the roadway makes its way up the western flank of the Wills Mountain Anticline. To the south, this same structure is breached to create Germany Valley (refer to Figure 15). The Tuscarora sandstone is exposed along the right-hand lane. At the top of the grade, you are on the axis of the Wills Mountain Anticline capped by the Tuscarora sandstone. In Maryland, the ridge is called Haystack Mountain while in Pennsylvania and West Virginia, it is known as Wills Mountain. This multiplicity of names for topographic features and rock units is common in geologic literature. In the case of the names assigned to rock units, for example, the differences are largely due to the fact that rock units were named in different areas before it was discovered that they were the same. In

other states, for example, the Tuscarora Sandstone is called the Medina while in others, the Shawangunk. Note that as you drive eastward, the Tuscarora sandstone can be seen dipping to the east as you descend the eastern limb of the Wills Mountain Anticline toward the axis of the Evitts Creek Syncline.

66.5 mi. US 220 overpass. As you descend from Haystack Mountain into the city of Cumberland, Maryland, the tan and rust-colored weathered shales of the Rose Hill Formation immediately overlying the Tuscarora sandstone can be seen along the east-bound lane with beds dipping to the southeast as you travel toward the axis of the Evitts Creek Syncline.

Cumberland is a city of approximately 24,000 inhabitants and was founded about 250 years ago on the site of a colonial fort guarding the National Road at mile 41.5 (Rt.40 and the Amish Road overpass). I-68 is elevated through town and gives excellent views of Knobbly Mountain to the south, Shriver Ridge to the north, and the Potomac River along the roadway to the right. Beyond Cumberland, you will observe relatively poor exposures of Mahantango shales and the overlying Brallier Formation. Cumberland was the westernmost end of the C&O canal which passed into history with the advent of the railroads.

68.9 mi. US 220 overpass (again). At this point, you are crossing the axis of the Evitts Creek Syncline. As you drove eastward from Cumberland, outcrops of the Devonian Brallier and Harrell formations were seen. The Brallier Formation consists primarily of rust-colored siltstones and shales while the Harrell formation consists of dark gray to black shales. Eastward beyond the US 220 overpass, the dark-gray siltstones and shales of the Mahantango Formation are encountered as you continue down-section. Low cuts in the eastbound lane expose the Keyser limestone with the Tonoloway limestone exposed on both sides of the road as you approach the Scenic US 40 overpass.

70.2 mi. Scenic US 40 overpass.

70.3 mi. East of Scenic US 40 overpass, the greenish-gray shales of the Rose Hill Formation appear in the next high road cut with moderate to steep westerly dips as you travel up-section through the west limb of the approaching Evitts Creek Anticline. At the far end of the cut, the Rose Hill shales are overlain by the rust-brown weathering Keefer sandstone. For the next mile or so, as you cross the nose of the Evitts Creek Anticline, the road cuts are dominated by the Rose Hill shales, some of them showing the overlying Keefer sandstone. Note the reversal in the dip of the beds as you cross the axis of the anticline. As you approach the Pleasant Valley Road overpass, the gray shales and thin limestones of the McKenzie Formation and the shales and limestones of the overlying Wills Creek Formation appear along the roadway as you continue up-section on the eastern limb of the Evitts Creek Anticline

74.1 mi. Pleasant Valley Road Overpass. Rocky Gap State Park is to the left.

76.8 mi. Crest of Martin Mountain. Approaching the crest of Martin Mountain, the pale-gray Tonoloway limestone is exposed in the east-bound lane. Rock Gap Lake can be seen to the right. Martin Mountain is an example of a synclinal ridge. The mountain is capped by the Oriskany sandstone. The Oriskany sandstone is important as a ridge-former throughout the Appalachian Mountains and also historically in that it has produced more gas and oil throughout the Appalachians than any other single rock unit.

We will take a very short detour at this point. Leave I-68 at Exit 52 and turn right on MD 144. Within less than a tenth of a mile, an excellent example of a symmetrical anticlinal structure in the Tonoloway limestone appears to your left. If you want to stop and take a closer look, immediately ahead there is an old scenic pull-off where you can park.

Continue on MD 144 toward Flintstone. To the left is a quarry in the Tonoloway limestone. The structure is a subsidiary fold on the east flank of Martin Mountain. East of the quarry, the trip crosses an anticlinal axis and as a result, the exposed rocks become increasingly younger as you drive toward the synclinal axis. Re-enter I-68 at Flintstone.

80.4 mi. Warrior Mountain. The roadway transects Warrior Mountain through a water gap eroded by Flintstone Creek. Warrior Mountain is capped by the Oriskany sandstone. In the water gap, the most conspicuous rocks are the Keyser limestones. At the top of the cut to the left, the large rock outcrop is an ancient coral reef.

83.4 mi. Crest of Polish Mountain. Polish Mountain is a synclinal mountain ridge with the topographic summit offset to the west of the axis of the Polish Mountain Syncline. From Warrior Mountain, you traveled up-section as you approached the axis of the syncline through the gray siltstones and limy siltstones of the Needmore Formation, through the dark shales and siltstones of the Mahantango Formation to the rust-colored siltstones and shales of the Brallier Formation and the Foreknobs Formation that caps the ridge. The highway grade on the west side of the ridge lies mostly on fill and outcrops are poor. The elevation at this point is 1246 feet (379 m). As you descend from Polish Mountain, the next 4 or 5 miles you will cross a broad belt underlain by rocks of the Brallier Formation, the rocks you saw in Lowe's parking lot. Although the overall structure is anticlinal, many smaller folds can be seen in the outcrops. In general, in the Valley and Ridge, the valleys are formed by shales and the ridges are capped by sandstones.

86.9 mi. Fifteen Mile Creek Bridge.

88.0 mi. Crest of Green Ridge. Traveling eastward from Fifteen Mile Creek, you will go up-section through the Brallier Formation to the Foreknobs Formation that caps the ridge. Deep road cuts on the east flank of Green Ridge shows the transition between the redbeds of the Hampshire Formation and the tan to gray sandstones and shales of the Foreknobs Formation. The elevation of Green Ridge is 1040 feet (316 m).

93.0 mi. Orleans Road overpass. Although poorly exposed, the rocks in this portion of the trip belong to the Hampshire Formation. Note the change in the dip of the rocks as you cross a synclinal axis. At this point you get an excellent view of the Sidling Hill gap along the eastern skyline. Nearly all of the rocks you observe along the roadway belong to the Hampshire Formation.

96.3 mi. Sideling Hill Creek Bridge. As you approach the Sideling Creek Syncline, the rocks will get progressively younger. The rocks underlying the bridge are those of the Hampshire Formation. Note the eastward dip.

98.8 mi. Crest of Sideling Hill. Without doubt, this is one of the most well-known and photographed outcrops in the Appalachians (refer to [Figure 16a & 16b](#)). When first opened, so many people were breaking the law by stopping to look at the structure that the State of Maryland finally decided to build a visitor center to accommodate the interested public. The ridge is a perfect example of a resistant caprock mountain along the axis of a synclinal structure. The excavation removed nearly 5 million cubic yards of material, exposing 850 feet of rocks belonging to the Purslane and Rockwell members of the Pocono Formation with the Purslane member capping the ridge. Although the exhibit center is no longer open, the overall geology of the area and is certainly worth a stop. Heading east, pull off into the parking area and walk across the bridge spanning I-68. If you approach from the east, you can exit I-68 directly into the visitor's center.

101.4 mi. Exit to Scenic US 40. The road to the left exposes shales and siltstones of the Mahantango Formation. Several exposures of the underlying Marcellus and Needmore shales have also been present along the road, but because they weather quite rapidly, the exposures are poor and probably can not be seen.

102.8 mi. Sandy Mile Road overpass. On the right are two abandoned quarries, one in the limestones of the Keyser Formation and the other in the Oriskany sandstone which caps the ridge. The fact that you have gone down stratigraphically over the past few miles indicates that you are approaching the axis of an anticline. Although the exposures are poor, the observed sandstone beds are probably those of the Keefer Formation with the anticlinal axis in the immediate area. The fact that I-68 ascends a long grade through the Wills Creek Formation approximately a half mile further east indicates that the anticlinal axis has been passed and that you are going up stratigraphically. The outcrops of east-dipping rocks along the roadway continue to become younger to the east as I-68 crosses outcrops of the Tonoloway limestone, limestones of the Keyser and Helderberg Formations and the Oriskany sandstone.

104.9 mi. I-68 separates from I-70

102.8 mi. Exit to MD 522. This might be a good point for a combination rest and food stop. Leave I-68 and exit into Hancock, MD. There are a number of good eating places along the main street. In addition, while you are in town, you might want to visit the C&O Canal visitors center that is just off the main drag to the right. After all needs have been satisfied, continue through town and re-enter I-68 (east) at the fruit and vegetable stand.

112.8 mi. US 40 and I-70 merge

114.7 mi. Ernstville Road overpass.

117.6 mi. Boyd Road overpass. Between the Boyd Road overpass and the MD 68 overpass, the roadway passes around the nose of Boyd Mountain. Boyd Mountain is capped by the Oriskany sandstone which can be seen in the cliffs just below the crest of the ridge. Boyd Mountain is the site of another major fault that places the Cambrian Conococheaque limestone against the Devonian Oriskany sandstone,

a displacement of about 8,000 feet (2432 m). At this point you have left the Appalachian Mountain Section of the Valley and Ridge Physiographic Province behind and have entered the Great Valley Section of the Valley and Ridge Physiographic Province.

121.8 mi. MD 68 overpass. Karst ridges of the Cambrian Conococheaque limestone can be seen in the adjacent pastures. Note the appearance of the cedar trees. Being lovers of alkaline soils, cedars are a sure sign that the underlying bedrock is limestone. In the next few miles, you will observe excellent exposures of the Ordovician Rockdale Run Formation, the Ordovician Pines Station dolomite, the Ordovician St. Paul limestone, the Ordovician Chambersburg limestone and the Ordovician Martinsburg Formation as you approach the synclinal axis near Conococheaque Creek.

126.3 mi. Conococheaque Creek. The creek flows through a series of tight meanders as it passes north to south along the outcrop belt of the Ordovician Martinsburg Formation.

127.5 mi. MD 63 underpass. The exposures along the road are the dark-gray siltstones and shales of the Ordovician Martinsburg Formation.

129.0 mi. I-81 turnoff. Outcrops in the pastures to the right are limestones belonging to the Ordovician Rockdale Run Formation.

132.7 mi. MD 65 underpass. Outcrops of the Ordovician Stonehenge limestone can be seen among the trees to the left. The low ridges to the left are capped by the Ordovician Stonehenge limestones. At this point, the Blue Ridge Mountains form the eastern skyline.

135.3 mi. US 40 overpass. Small outcrops of the Conococheaque limestone and Tomstown limestones can be seen in the fields. Typical of areas underlain by limestones, the region exhibits the sinkholes typical of karst topography (see [Figure 18](#)). Also common to regions underlain by extensive limestones, the soils are quite thin and are stained red by the iron contained in the insoluble portions of the limestones that is released as the calcareous materials dissolve. One can only imagine Civil War soldiers, both Blue and Gray alike, passing this way and thinking that these rocks could provide a bit of protection if they were fired upon.

137.8 mi. MD 66 overpass. Poor outcrops of the Cambrian Elbrook limestone can be seen in the pastures to the north of the highway. At this point in your trip, you are approaching the easternmost limit of the Great Valley Section. South Mountain, the first prominent ridge of the Blue Ridge Physiographic Province forms the eastern skyline.

141.8 mi. The crest of South Mountain. South Mountain is one of the ridges of the Blue Ridge Physiographic Province and is held up along most of its length by the west-dipping Cambrian Weverton Quartzite; unfortunately it is cut out by faulting at the location of the I-70 crossing. The spectacular view to the east from this vantage point is the Middletown Valley between South Mountain and Catoctin Mountain. The valley is floored by the metabasalts of the pre-Cambrian Catoctin Formation, excellent exposures of which will be seen at Catoctin Mountain. These rocks represent the core of a gigantic fold called the South Mountain Anticlinorium. An anticlinorium is a very large anticlinal

structure within which the rocks have been subjected to complex folding and faulting. The walking bridge that crosses the roadway carries the Appalachian Trail.

144.6 mi. The outcrops along the right-hand lane are greenstones formed by the metamorphism of the basalts. When wet, the rocks are dark-green in color due to the mineral content, especially the presence of chlorite.

150.7 mi. The crest of Catoctin Mountain. Another of the ridges of the Blue Ridge Physiographic Province, Catoctin Mountain is capped by resistant metabasalts of the pre-Cambrian Catoctin Formation, a thick sequence of basaltic and rhyolitic lavas extruded during the late pre-Cambrian and metamorphosed to the observed foliated greenstones during an ancient continent-continent collision. The white veins and pods are quartz while the green ones are epidote. As you drive down the eastern slopes of Catoctin Mountain, outcrops of the Cambrian Weverton Formation are common with a high road cut along the east bound lane showing several outcrops and much quartzite rubble.

Rt. 40 exit: At this point, you have left the Blue Ridge Province and entered the Piedmont. The Rt. 40 exit is an excellent geologic route despite the very heavy traffic day and night. In the 1970s, this area was not yet overrun by development. Carbonates and the Triassic deposits were to be seen everywhere. Now you can stop to eat and buy most anything but the rock outcrops are conspicuous by their absence. We urge you to travel east-bound along the four-lane divided highway and pull into the parking lot of either the Pep Boys or Pier One. The rocks exposed here are real and in place. These are the coarse-grained Triassic **diamicts** (pebble- and cobble-sized sub-angular carbonate fragments in a matrix that was mud during the Triassic). The rocks show “bedding” planes that dip! Packages of rock and mud flowed off the highlands to the west. Look back to the Blue Ridge and imagine much higher mountains towering above and capped by Cambrian and Ordovician carbonates over 200 million years ago! Debris flows, perhaps triggered by heavy rains and snow melt and/or earthquakes flowed down the steep slopes into the Triassic Basins that formed by tensional forces that were set into play as North America broke away from the super-continent of Pangea 200 million years ago (refer to Figure 2). As the basins continued to form, thousands upon thousands of feet of sediment accumulated! From time-to-time, lakes formed in the basins and dinosaurs came down to drink only to leave their footprints in the mud. Not far away, in Virginia, over 10,000 feet (3040 m) of sediment accumulated in such an environment.

153.5 mi. Mt. Philip Road overpass. Between Mt. Philip Road and the US 340 underpass, the roadway crosses the Triassic red sandstones, limestones, conglomerates, and igneous intrusions which typically are not seen in outcrop but whose presence can be seen in the bright red color they impart to the soils. This is also the location of a concealed fault that establishes the contact between the Triassic rocks and the Cambrian Araby Formation. During the Triassic, as the newly formed continents were being rifted from the super-continent Pangea, tensional forces generated normal faults that resulted in the formation of basins which were rapidly filled by erosion of the adjacent highlands

(Figure 26). Evidence that the sediments were rapidly transported, deposited, and buried is indicated by the presence of arkoses, feldspar-rich sandstones. Had the sediments not been rapidly buried, the feldspars would have been decomposed to clay minerals. In several areas, especially Pennsylvania, Virginia, and the Connecticut Valley, sediment surfaces have preserved the tracks of dinosaurs that roamed the area during the Triassic.

154.6 mi. US 340 underpass.

155.5 mi. US 270 underpass

157.3 mi. Genstar Stone Products quarry. The quarry operates in the Cambro-Ordovician Grove limestone. What is often sold as “Frederick Marble” when polished or “Frederick Carbonates” as aggregate is known to geologists as “inlier”. Although undoubtedly correlative to the Cambrian-Ordovician carbonates west of the Blue Ridge, the lack of fossils has made it too problematic to correlate these rocks directly to the rock names west of the Blue Ridge.

Frederick, Maryland. A few miles east of Frederick, Maryland, the rocks become covered by regolith and soil, obscuring any possibility of rock outcrops. For this reason, the trip will terminate in Frederick.

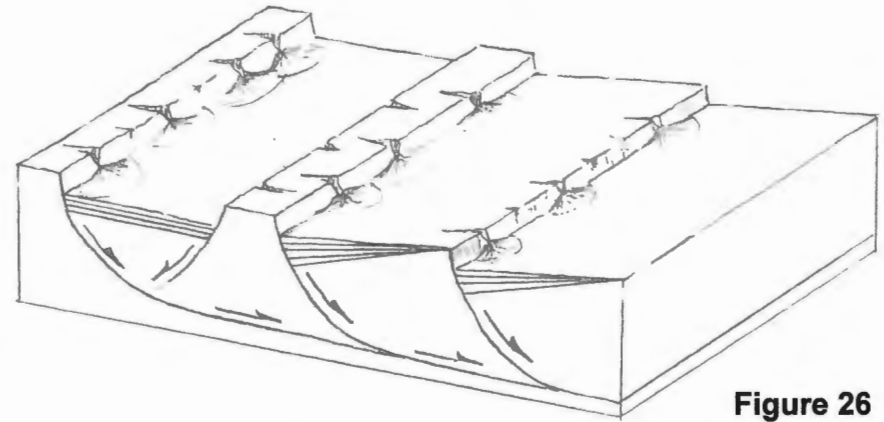


Figure 26

MAJOR RIDGE-FORMING SANDSTONES

Pottsville Sandstones (basal Pennsylvanian)- most topographic highs within the Appalachian Plateau

Pocono Sandstones (basal Mississippian) - exposed along the Allegheny Structural Front in the Fore Knobs

Oriskany Sandstone (lower Devonian) - forms many minor ridges within the Valley and Ridge

Tuscarora Sandstone (basal Silurian) - the major ridge-former in the Valley and Ridge Province

MAJOR RED-COLORED ROCKS

Mauch Chunk (upper Mississippian) - widely exposed in Appalachian High Plateau and along the Allegheny Structural Front

Hampshire Formation (upper Devonian) - widely exposed within the Valley and Ridge

Juniata Formation (upper Ordovician) - exposed in Valley and Ridge water gaps below the Tuscarora Sandstone

A GEOLOGY FIELD TRIP

by

Dr. John J. Renton
Dept. of Geology and Geography
West Virginia University

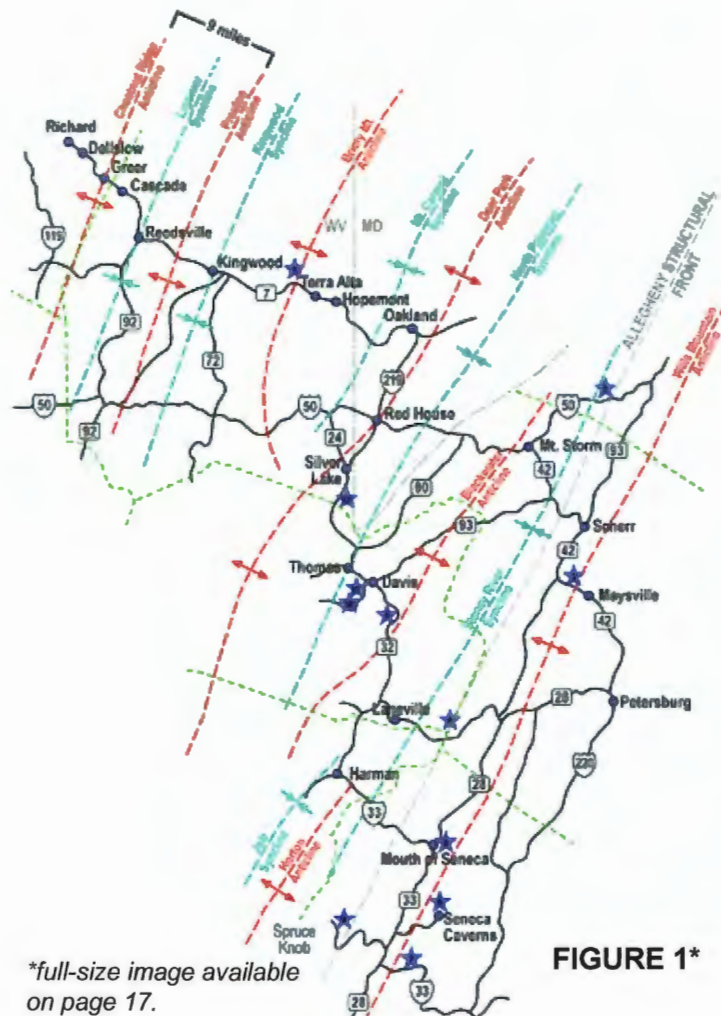


FIGURE 1*

*full-size image available
on page 17.

Introduction to Field Trip

I had several objectives in mind when I prepared this field trip. I want to develop in you an interest, an understanding, and an appreciation of geology of the region. I want to show you differences between three of the basic physiographic provinces within Appalachia, the Low Plateau, the High Plateau, and the Appalachian Mountain Section of the Valley and Ridge Province. I also want to show you the role that the kinds and structures of the underlying rocks plays in the formation of the topography of a region in order to have you better understand why the appearance of the land changes as you travel about the country. During the trip, you will also see excellent examples of the process of weathering as well as the erosive power of streams. The trip will visit several tourist areas and, in addition to their scenic beauty, you will learn that they represent excellent examples of important geologic features.

ROAD LOG

Introduction: As you begin the trip, there are two figures you will want to keep handy; Figure 1*, which is the road map showing the path of the trip and Figure 2 which is the stratigraphic column that lists all of the rock formations you will encounter on the trip and their

FIGURE 2

Rock Units Observed During Trip	Period	Pottsville Group	
		Middle	Lower
Mississippian	Upper	Mauch Chunk Group	
		Greenbrier Group	
	Lower	McCarty Fm	
		Price Fm (Pocono)	
Devonian	Upper	Harrington Group	
		Huron	
		Foreknobs (Chemung)	
		Brallier Fm	
	Middle	Hartell Fm	
		Manhattan Fm	
		Marcellus Shale	
	Lower	Onondaga Limestone	
		Huntsville Chert	
		Needmore Shale	
Silurian	Upper	Onondaga Sandstone	
		Helderberg Group	
		Tonoloway Limestone	
		Willis Creek Fm	
	Middle	Newburg Fm	
		Williamsport Fm	
		Barnesburg Fm	
	Lower	Lockport	
		McKenzie Fm	
		Keefer Sandstone	
Ordovician	Upper	Rose Hill Fm	
		Tuscarora Sandstone	
		Juniata Fm	
	Lower	Reedsville Fm	
		Trenton Group	
		Black River Limestone	

FIGURE 3

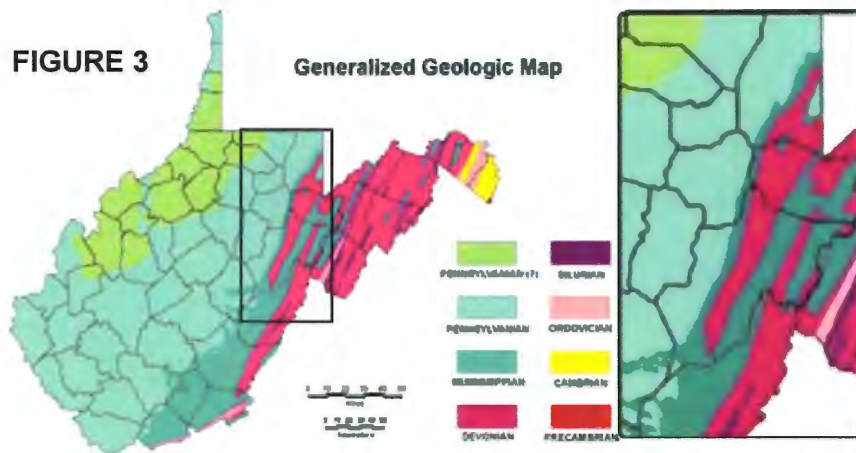


FIGURE 4

relative ages. I have also provided the Geologic Map of West Virginia (Figure 3) and an enlargement of the portion of the geologic map that we will be traversing in our trip (Figure 4). Other figures are provided which are designed to provide you with more detailed information about the geology you will be seeing at individual stops.

Morgantown, WV

At Morgantown, you are near the eastern boundary of the Appalachian Low Plateau (Figure 5). All of the rocks you observe in road cuts west of Morgantown are Pennsylvanian in age and consist primarily of inter-layered sandstones, shales, and coals with a limited number of limestones. The Low Plateau is underlain by very low amplitude, symmetrical folds. In fact the amplitudes of the folds are so low that the beds of the exposed rocks appear horizontal. In contrast, while the structures within the High Plateau, while still symmetrical, have amplitudes that are high enough to appear as distinct northeast-southwest trending ridges such as Chestnut Ridge. With the summit approximately 1,000 feet (300 m) higher than Morgantown, Chestnut Ridge Anticline forms the eastern skyline as you approach Morgantown from the west.

Note: a majority of the illustrations are provided to illustrate a geologic concept. They have no implied scale unless otherwise noted.

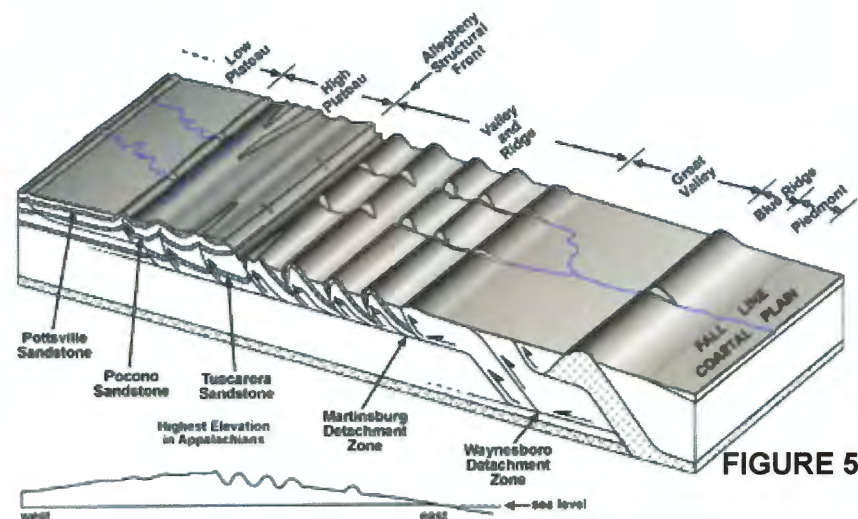


FIGURE 5

Morgantown, WV, to Dellslow, WV

Proceed to Sabraton and continue east on WV Rt 7. The portion of the trip from Morgantown to Kingwood can be followed on the cross section and map shown in Figure 6*. All of the rocks throughout the

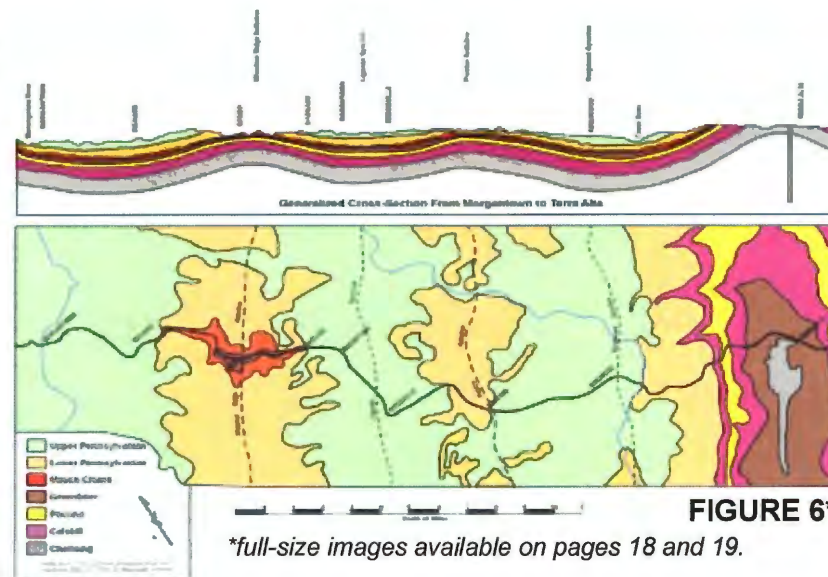


FIGURE 6*

*full-size images available on pages 18 and 19.

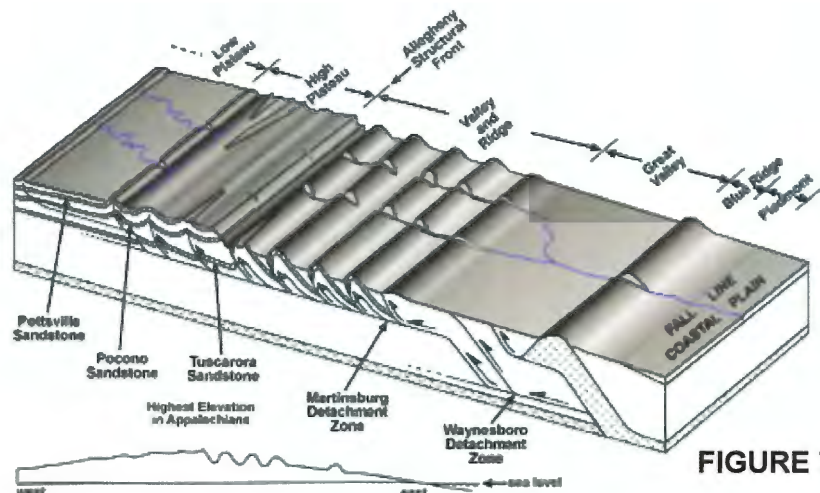
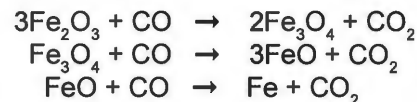


FIGURE 7

Low Plateau and most of the rocks you will see as you cross the High Plateau belong to the Pennsylvanian System which contains the coal beds for which Appalachia is famous. Many of the smaller towns within the region were coal towns. For example, the first small town through which the trip passes, Richard, had a small coking industry during the first half of the last century. Coals mined in the area were roasted in beehive ovens to drive off the volatiles and create coke. Coke is used in the steel industry to separate the iron from the iron ore in blast furnaces. The coke oxidizes in the furnace to produce carbon monoxide, CO, which then reacts with the iron ore, Fe_2O_3 , to release the iron in a molten state:



The ovens were eventually shut down because they became uneconomical to operate and because the vapors generated during the coking process were an environmental hazard.

As the trip crosses Decker's Creek at Dellslow, West Virginia, you are leaving the Appalachian Low Plateau and entering the Appalachian High Plateau (Figure 7). At this point, you are at the western base of the first major structure of the High Plateau, the Chestnut Ridge Anticline. The Chestnut Ridge Anticline extends about 85 miles (137 km) from Uniontown, Pennsylvania, to Weston, West Virginia.

Dellslow, WV to Greer, WV

At Dellslow, the trip enters the water gap that Decker's Creek has cut through the Chestnut Ridge Anticline (refer to Figure 6). The large blocks of rock that appear along the roadway and in the creek were dislodged by physical weathering processes such as frost wedging from the Pottsville sandstone that arches over the Decker's Creek valley. The Pottsville sandstone is the first of several resistant sandstones you will see on the trip. The rock consists of quartz grains tightly cemented together by quartz. In places, conglomerates appear within the sandstone beds. If you've ever been to the overlook at Cooper's Rock, you were standing on the Pottsville sandstone very near the axis of the Chestnut Ridge Anticline, looking down into a classic V-shaped valley carved by the Cheat River. The Pottsville sandstone is the major ridge-former within the High Plateau. As the trip progresses across the High Plateau, you will see exposures of the Pottsville sandstone many times.

Note that as you enter the water gap, the bedding of the rocks dip toward you, meaning that you are approaching the axis of an anticline (Figure 8). As you drive toward an anticlinal axis, the individual rock units are getting progressively older. A geologist would say that you are "going down stratigraphically." As you drive through Decker's Creek water gap, note how narrow the stream appears to be relative to the dimensions of the valley. This points out that, given enough time, a small stream such as Decker's Creek is still a potent agent of erosion.

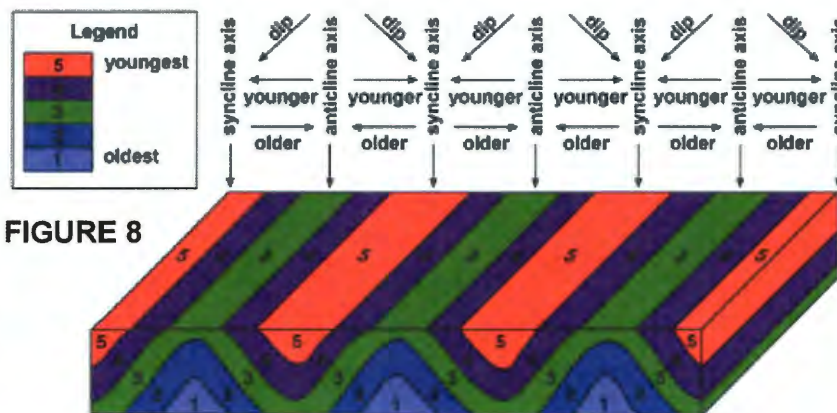


FIGURE 8

As you continue into the water gap, the next rock sequence to appear below the Pottsville sandstone, the Mississippian Mauch Chunk Formation, consists of interbedded sandstones and shales. Unfortunately, the Mauch Chunk is not well exposed along the roadway. The Mauch Chunk Formation is the first of three “red bed” formations you will see today. The red color of the sandstones and shales is due to coatings of hematite, Fe_2O_3 . Geologists interpret the red beds you will see on this trip as indicating that the original sediments were deposited in shallow, highly oxygenate waters that promoted the precipitation of the iron oxides.

As you approach Greer, the road will make a right-angled turn to the left. The rock on your left, looking like a wall, is the Mississippian Greenbrier limestone. The surfaces of the blocks are excellent examples of joints. Joints are breaks in rocks perpendicular to bedding along which there has been no measurable movement. The blocks that you see in the outcrop were formed by the intersection of two sets of mutually perpendicular joints. While all rocks exhibit joints, few are as well exposed as these. The Greenbrier limestone is the oldest rock formation exposed in the Decker’s Creek water gap. Shortly, you will pass the Marquette Cement mine and a mile or so later, the mine of the Greer Limestone Corporation. Both operations are mining the Greenbrier limestone. The rock produced at Greer is largely used for road construction and as the aggregate in concrete. The limestone mined at Greer is also mixed with high-purity limestone from Greer’s Germany Valley quarry and ground into a fine powder to make agricultural lime. Agricultural lime is the white powder you see spread over yards and gardens during the spring to both neutralize the acid soils we have in this region and to provide the calcium nutrients that many of the plants you want to grow in your garden and lawn need; grass being one of them. The trip will visit Germany Valley later in the day.

As you passed through Greer, you crossed the axis of the Chestnut Ridge Anticline. As a result, as you continue through the water gap, you will notice that the bedding of exposed rocks dip away from you, meaning that you are now approaching the axis of the Ligonier Syncline (refer to Figure 8). Because the rock units get progressively younger as you approach a synclinal axis, you are said to be “going up stratigraphically”.

Greer, WV to Reedsville, WV

Beyond Greer, the Pottsville sandstone appears once again along the road as it “comes down” on the east limb of the Chestnut Ridge Anticline. The road map in Figure 1 shows a town called Cascade which no longer exists. Originally, Cascade was the eastern equivalent of Richard in that both used local coals to generate coke in beehive ovens.

Note how the topography becomes more subdued as you drive toward Reedsville and how it resembles the topography around Morgantown. The similarity is an excellent example of how rock type and structure determine topography. The similarity is due to the fact that the same sequence of rocks are exposed in both areas plus the fact that the rock layers are essentially horizontal. In the case of the region near Morgantown the beds are horizontal because it is located in the Low Plateau where the amplitudes of the folds are so low that the bedding is essentially horizontal. In the case of the drive to Reedsville, the rock layers become more horizontal because you are crossing the axis of the Ligonier Syncline. In summary, similar rock types and bedding attitude create similar topography.

Reedsville, WV to Kingwood, WV

At the 4-way stop in Reedsville, turn left toward Kingwood. As the trip continues toward Kingwood, you will note several changes in the landscape. For one, the topography begins to rise and become more rugged. In addition, large sandstone boulders and outcrops of the Pottsville sandstone begin to appear along the roadway and in the fields. The reason for what you see is because you are approaching the axis of the broad Preston Anticline (see cross section in Figure 6). Because the amplitude of the Preston Anticline is nowhere near that of either the Chestnut Ridge Anticline to the west or to those you will see to the east later in the trip, the only affect of the structure is a broad arching of the landscape and an increase in the ruggedness of the topography as the Pottsville sandstone along the axis of the fold begins to be exposed at the surface. However, because the dip on the rocks associated with the broad Preston Anticline are low, the exposure of the Pottsville sandstone

does not form any dominant ridges. As you cross the High Plateau, time and time again you will see the influence of the Pottsville sandstone on the topography. In fact, anytime the topography becomes more rugged and sandstone outcrops appear as you cross the High Plateau, you can count on it being due to exposures of the Pottsville sandstone.

Kingwood, WV to Briery Mountain

As you approach Kingwood, Briery Mountain forms the skyline to the east. At Kingwood, you will cross the Kingwood Syncline and descend to the valley of the Cheat River. At this point, you are at the western base of Briery Mountain. Note from the cross section in Figure 6 that the Briery Mountain Anticline is a very large structure and that it has been "breached". Being breached means that the resistant rocks that formed the crest of an anticline have been removed by erosion, exposing the softer, more easily eroded rocks below. In the case of the Briery Mountain Anticline, the Pottsville sandstone was breached allowing the rocks as old as the Devonian Chemung Formation to be exposed along the axis of the fold (Figure 9).

The large size of the Briery Mountain Anticline, as compared to those that you have crossed up to this point, becomes evident as you

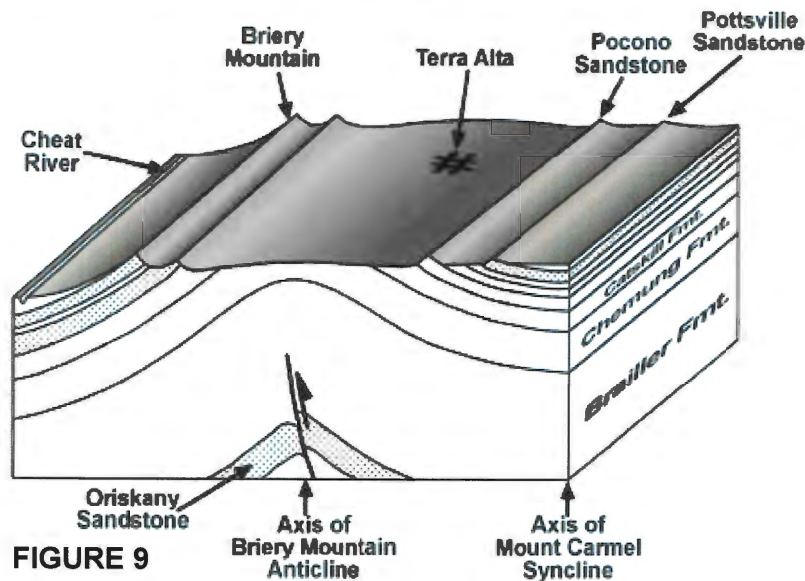


FIGURE 9

climb the long, steep roadway to the top. Because of the breaching of the main structure, Briery Mountain is a monoclinal ridge, that is, it is underlain rock layers that dip in one direction, in this case, to the west. Because the slope of the roadway and the angle of dip of the western limb of the structure are about the same, outcrops of the Pottsville sandstone are more or less continuously exposed along the ascent.

Briery Mountain to Stop #1.

After reaching the top of Briery Mountain at an elevation of 2,704 feet (834 m), the roadway drops into a small valley underlain by the Mississippian Greenbrier limestone. The Greenbrier limestone is the same rock layer mined at the Marquette and Greer mines you passed earlier along Decker's Creek. The valley is an excellent example of how the low resistance of limestone to chemical weathering results in the formation of valleys. Later in the day, you will see two other examples of limestone valleys, Canaan Valley and Germany Valley. The ridge just beyond the small valley is due to the appearance of the next oldest major sandstone unit that you will see today, the lower Mississippian Pocono sandstone. The Pocono ridge, like Briery Mountain, is a monoclinal ridge on the west flank of the breached Briery Mountain Anticline.

After crossing the Pocono ridge, the rocks exposed along the roadway and the soil turn a noticeable red color due to the outcropping of the Devonian Hampshire Formation. The Hampshire Formation is the second of three dominant red bed units you will see today. Beyond the outcrops of the Hampshire Formation, the topography becomes increasingly subdued as you approach the axis of the anticline due to the combination of intermixed, flat-lying sandstones and shales of the Devonian Chemung Formation.

Stop #1

As you crest the hill, the roadway will turn down and to the right. In the bend, there is a pull-off to the left. At this point, stop and walk up through the field to the top of the hill; a distance of a few tens of yards. Assuming that it is a clear day, you will be looking back along the field trip route as it crossed the High Plateau. Not only will you be able to see Chestnut Ridge along the western skyline, but also the topographically lower Preston Anticline between your vantage point and the Chestnut

Ridge Anticline. There are few places where you can get this kind of geologic perspective.

I might also point out that you are standing over the Terra Alta gas field. In its day, the Terra Alta gas field was one of the most productive gas fields in the Appalachians. Today, it is used for gas storage. The local gas company buys gas during the summer when the demand and price is low, pumps it back underground into the original reservoirs for storage, and withdraws it during the winter when demand increases..

Stop#1 to Oakland, Md

From Stop #1, travel eastward through Terra Alta (pronounced by the natives as one word - Tearalta) to Hopemont. As you make the turn to the right at the Hopemont Hospital, the land drops slightly in elevation. At this point, you have dropped off the Pocono ridge on the eastern limb of the Briery Mountain Anticline back down into a Greenbrier limestone valley. The topography here is much more subdued than that which you observed on the western side of the structure because of the lower angle of dip of the eastern limb of the structure. From Hopemont, you will cross the Mt. Carmel Syncline and enter the breached Deer Park Anticline as you continue to Oakland, Maryland (Figure 10). Along the way, you will once again see evidence of the Pottsville sandstone cropping out to the surface and forming the major ridges.

Oakland, Md to Red House, Md

Drive through Oakland on WV Rt. 7 and turn south on US 219 toward Red House. The roadway parallels the axis of the breached Deer Park Anticline. The skyline to the east (your left) is Backbone Mountain, a monoclinal ridge underlain by the east-dipping Pottsville sandstone on the east limb of the structure (refer to Figure 10). The rocks throughout the valley are largely the flat-lying sandstones and shales of the Chemung Formation, once again giving rise to the gently rolling topography.

Red House, Md to the Allegheny Structural Front

At Red House, turn east on US 50. From Red House to Mt. Storm, you will cross the North Potomac Syncline and the Blackwater Anticline (refer to Figure 10). Note how the topography becomes increasingly rough as you drive eastward with the familiar blocks of the Pottsville sandstone beginning to appear along the roadway. What most individuals are not aware of as they drive eastward across Appalachia is the fact that the elevations have progressively increased. The elevation of Morgantown is about 900 feet (275 m) above sea level. By the time you get to Mt. Storm and the Allegheny Structural Front, elevations will have increased to about 5,000 feet (1,525 m) above sea level. The Allegheny Structural Front is the line of demarcation between the Appalachian Mountain Section of the Valley and Ridge Physiographic Province and the High Appalachian Plateau.

Perhaps this would be good time to summarize what you have seen so far. The trip started at the eastern margin of the Appalachian Low Plateau which extends westward to Ohio. Structurally, the Low Plateau is underlain by symmetrical folds with amplitudes so low that the rock beds appear to be horizontal. The rocks throughout the Low Plateau are a mixture of sandstones, shales, and coals. Beginning at Dellslow, you entered the Appalachian High Plateau. While the dominant structures are still symmetrical folds, the amplitudes of most of the folds of the High

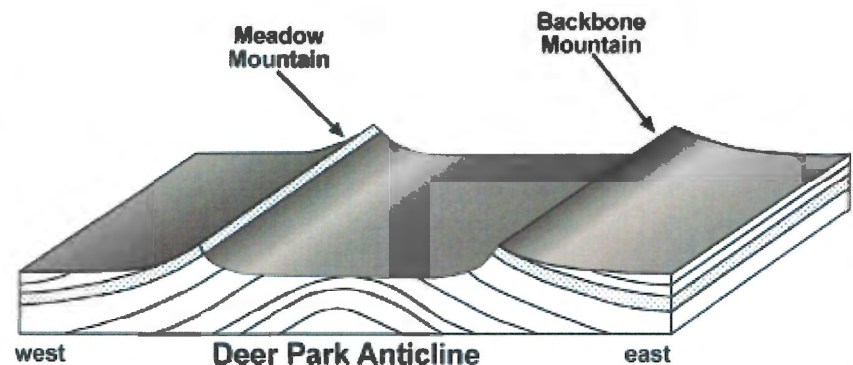


FIGURE 10

Plateau are high enough to produce anticlinal ridges, some of which are breached to form parallel monoclinal ridges. The erosion of the higher amplitude folds brought the resistant Pottsville sandstone to the surface where it was responsible for most of the ridges and much of the rugged topography that characterizes the High Plateau.

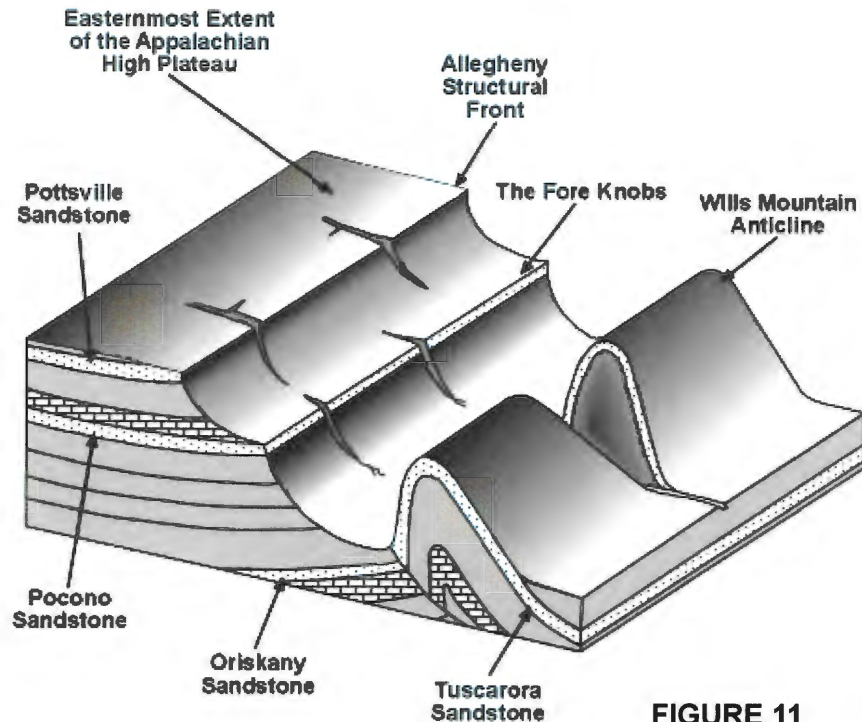


FIGURE 11

Stop #2

Just beyond Mt. Storm, you will arrive at the Allegheny Structural Front (Figure 11). At the very edge of the Front, there is a scenic overlook along US Rt. 50 to the right that will provide you with a spectacular overview of the Appalachian Mountains. The ridge before you is Wills Mountain Anticline, the westernmost structure of the Appalachian Mountain Section of the Valley and Ridge Physiographic Province. On a clear day, you should be able to see several ridges beyond Wills

Mountain to the east. The notch that appears along the summit of Wills Mountain is called a wind gap. A wind gap began as a stream valley that was being carved across an anticline as the region was being uplifted. At some point, however, the rate of down-cutting by the stream was not able to keep up with the rate of uplift of the land. Eventually, the stream separated into two streams flowing down opposite sides of the ridge, leaving a wind gap behind. As a bit of historic trivia, Abraham Lincoln's mother was supposedly born beyond the wind gap on the eastern side of Wills Mountain.

Allegheny Structural Front to WV Rt. 93

You are now about to enter the Appalachian Mountain Section of the Valley and Ridge Physiographic Province. The dominant structures within the Appalachian Mountains are asymmetric to slightly overturned anticlinal folds, with the steep western limb commonly broken by high-angle thrust faults (Figure 12). Most of the mountains consist of long narrow anticlinal ridges capped by the Silurian Tuscarora sandstone with the adjoining synclinal valleys underlain by soft Devonian shales. As was the case with the High Plateau, many of the anticlinal structures are breached, forming monoclinal ridges on opposite sides of valleys underlain by Ordovician limestones.

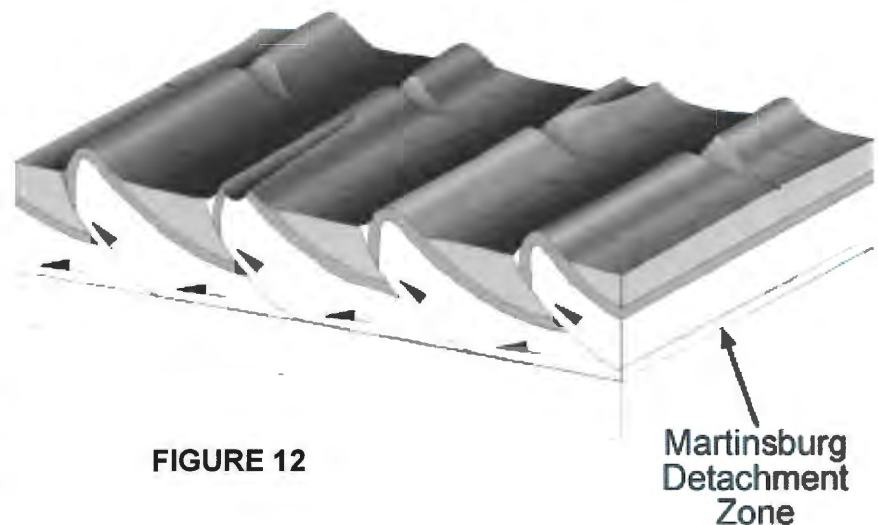


FIGURE 12

Martinsburg
Detachment
Zone

Continue on US Rt. 50 beyond the Front. As you descend the Front, you will drop below the Pottsville sandstone that caps the edge of the Front and pass through the red beds of the Mauch Chunk Formation. After passing through most of the Mauch Chunk red beds, the roadway encounters a relatively flat ledge known as the Fore Knobs (refer to Figure 11). The Fore Knobs are held up by the second resistant sandstone you saw on Briery Mountain, the Pocono sandstone. Above the Pocono is the Greenbrier limestone which accounts for most of the Fore Knobs being a grassy pasture. The dissolution of the limestone provides the calcium ions that grass prefers as a nutrient. During the early settlement of the region, the pastures of the Fore Knobs were supposedly used to graze cattle.

At this point in your descent from the Front, you will see a sign warning truck drivers to "stay in low gear". All too often, truckers unfamiliar with the road reached the flattened portion of the roadway on the Fore Knobs after dark and considered that they have completed the descent from the Front and shift to high gear. Unfortunately, the worst grade is yet to come. Once beyond the Fore Knobs, the roadway descends steeply through the red beds of the Hampshire Formation, the sandstone and shales of the Chemung Formation, the rust-colored shales and sandstones of the Brallier Formation and at the bottom of

***** A word of caution: Because of the steep grades and hairpin turns, this stretch of road is extremely dangerous. Keep in mind that historically the main cause of accidents has been brake failure. I want you to enjoy the geology and the scenery, but not at the price of your life ***.**

the grade, the black shales of the Hamilton-Marcellus Formation. Note that as you descend from the Fore Knobs, the beds begin to dip toward you at progressively increasing angles from nearly horizontal at the Pocono outcrop to very steep at the bottom of the grade. This increase in dip reflects your approach to near-vertical western limb of the Wills Mountain Anticline.

WV Rt. 93 to Scherr, WV

At the intersection of US 50 and WV Rt 93, turn south on WV Rt. 93 to Scherr. You will be driving down a valley underlain by the black shales of the Devonian Hamilton-Marcellus Formation. The Hamilton-Marcellus Formation underlies most of the synclinal valleys in the Appalachian Mountains. Several places along the roadway, the Devonian Oriskany sandstone forms a small anticlinal structure called the Hopewell Anticline, on the western flank of the main Wills Mountain Anticline.

The Oriskany sandstone has played an important economic role in West Virginia. Within the Appalachian Plateau, the Oriskany sandstone reservoir produced more petroleum during the early years of the petroleum industry than any other single reservoir. For example, the Oriskany was the source of gas in the Terra Alta field. In most cases, the Oriskany sandstone is a calcareous sandstone which means that the quartz grains are cemented together by calcite, CaCO_3 . At a quarry outside Berkeley Springs, West Virginia, however, the Oriskany is an ultra-pure quartzose sandstone with the quartz grains cemented by quartz. Sandstone from the quarry have long been used for the production of fine glass and crystal. In fact, it was Oriskany sandstone from the Berkeley Springs quarry that Corning Glass used to cast the glass disc that was used to make the reflecting mirror for the Mt. Palomar telescope.

Scherr, WV to Maysville Gap

At Scherr, continue southward on WV Rt 42 toward Maysville and Petersburg. Just south of Scherr, WV Rt. 42 will turn east into Maysville Gap, a water gap carved through Wills Mountain Anticline. As you enter the gap, you will have your first view of the Tuscarora sandstone exposed in the nearly vertical western limb of the structure. The Tuscarora sandstone is the major ridge-former throughout the Appalachian Mountains. As you pass through the gap, the Tuscarora can be seen to arch high above the valley floor. The sides of the gap are covered with scree consisting of blocks of rock broken from the

Tuscarora cliffs above. At places along the roadway, you will be able to see outcrops of the third major formation of redbeds, the Juniata Formation, that underlies the Tuscarora sandstone. As you near the eastern end of the watgap, the Tuscarora sandstone forms some spectacular waterfalls. If you have time, stop within the gap and enjoy the beauty of the geology and of the stream.

Maysville Gap to Petersburg, WV

As you emerge from the eastern end of Maysville Gap, you will notice the more gently-dipping eastern limb of the structure as the Tuscarora sandstone returns to road level. Comparing the attitudes of the vertical western limb and the more gentle eastern limb gives you a feeling for the asymmetry of the structure. Shortly beyond the Tuscarora outcrop, you will once again encounter the Oriskany sandstone, this time in the form of a monoclinial ridge called a hog back. Beyond the Oriskany ridge, you will enter a synclinal valley between the Wills Mountain Anticline to the west and the Patterson Creek Anticline to the east. The valley is underlain by shales of the Brallier and Hamilton-Marcellus formations.

Locally, this valley is known as “The Barrens” or “The Shale Barrens” because of its scarcity of trees. The reason for the lack of large plants is because, being located in the rainshadow of both the Front and Wills Mountain, the annual precipitation for the valley is less than 20 inches (50 cm). According to my botanist friends, 20 inches of annual precipitation is the absolute minimum for the survival of most trees. While the valley certainly doesn’t qualify as a desert, as you drive southward, keep an eye out for cacti that commonly grow along the fence lines.

Petersburg, WV to North Fork Gap

Driving south, the roadway parallels the monoclinial Oriskany ridge and Wills Mountain. Just outside Petersburg, turn west at the intersection with WV Rt. 28 toward North Fork Gap. As you drive toward the gap, you will be able to clearly see the monoclinial Oriskany ridge in the foreground and the Tuscarora sandstone arching high over the gap. The Allegheny Structural Front makes up the skyline to the west. The

next stop, Dolly Sods, is located along the portion of the Front that you can see beyond the water gap.

North Fork Gap to Dolly Sods

As you exit North Fork Gap, you will once again see the vertical western limb of the Tuscarora sandstone. To your right, you will pass Smoke Hole Caverns which are commercial caves within the vertical outcrop of the Silurian Tonoloway limestone. The Oriskany sandstone will once again appear along the roadway. After a mile or so, Jordan Run Road will enter on your right. Turn right onto Jordan Run Road and bear left at the intersection. Over the next few miles, you will re-climb the Front. Try to identify the various rock units along the way. You should be getting pretty good at recognizing many of the rock units by now.

Once on top of the Fore Knobs, the road will run parallel to the Front for a few miles. There are several places along the roadway that you may want to stop and just enjoy the scenery and think about all of the geology that you have seen.

Stop #4: Dolly Sods

As you reach the summit of the Front, you will come to a T-intersection. Turn right and after a few yards, pull off the road and park at an information board that will give you the usual historical information about the area. Do not go to the “official” overlook which is further down the road; there is one that is infinitely better. Facing east, you will see a line of conifers that come out nearly to the road. To the left is an open area of low bushes and brambles. Keeping the conifers to your right, head out across the open area. As you cross the area, you will see a low-growing plant commonly called “ground pine”. This plant is the only descendent of a once majestic tree, *Lepidodendron*, that 300 million years ago was a major contributor to the peats that eventually became the coals of the eastern United States. You will see some fossil remains of *Lepidodendron* later at a stop on Canaan Mountain.

On you way to the edge of the Front, you will encounter large tilted blocks of the Pottsville sandstone. The most widely held explanation for their origin is that during the maximum advance of the Pleistocene ice sheet, which never got anywhere near where you are, the peri-glacial

climatic conditions that existed throughout most of Central and Northern Appalachia resulted in intense frost wedging the broke the layers of Pottsville sandstone that were exposed at the surface into blocks and left them in the jumbled array you now see. Within a hundred yards or so, you will come to the very edge of the Allegheny Structural Front where you can sit on the Pottsville outcrop that makes up the edge of

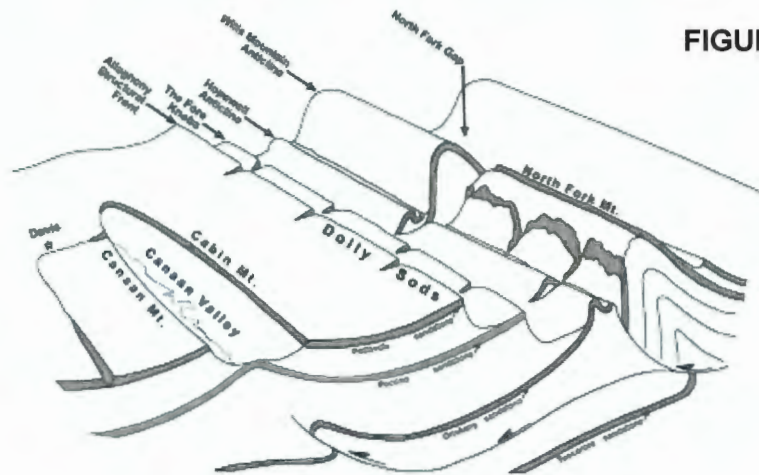


FIGURE 13

the Front and dangle your legs over the edge. I have provided a block diagram of the area for you to illustrate all that you will see from this vantage point (Figure 13).

Behind you, the Appalachian High Plateau stretches away to the west with Cabin Mountain making up the skyline. Beyond Cabin Mountain lies Canaan Valley and Canaan Mountain, both of which you will visit later in the trip. This place is called Dolly Sods after the Dolly family that settled here. Can you imagine what it must have been like living along the Front during those early days? The stunted growth of trees clearly indicates it experienced severe weather. Having made a winter backpacking trip onto the Sods, I can attest to how cold it can get. The trees with limbs only on the eastern side attests to the strong westerly winds that commonly whip the area. You should not be surprised to be told that another name for this place is "The Roaring Plains".

The reason for coming to this spot is the view to the east. Before

you is the most spectacular view of the Valley and Ridge Province I have ever seen. It almost speaks for itself. This place is what geology is all about. On a clear day you can see several ridges beyond Wills Mountain. Looking back through North Fork Gap toward Petersburg, note that the Tuscarora sandstone on the north side of the gap arches unbroken across the entire ridge. To the south of the gap, however, the structure has been breached with the Tuscarora sandstone having been eroded away along the summit. The outcrop of the Tuscarora along the eastern limb of the structure continues southward as North Fork Mountain while, along the western side of the structure, the Tuscarora sandstone forms a series of vertical outcrops separated by V-shaped notches carved out by streams flowing off the western side of the mountain. But why is the southern portion of the anticline breached while the northern portion is not? There is evidence that many, if not most, of the water gaps cutting across the ridges of the Appalachian Mountains are the sites of vertical faults that actually provided the zones of weakness sought out by the streams to carve their channels when the region was uplifted over the past 60 million years. In the case of North Fork Gap, the southern side of the fault was uplifted more than the northern side, resulting in the southern portion of the structure experiencing more intense weathering and erosion than the northern portion of the structure. Eventually, the combined efforts of physical weathering, mass wasting and erosion carved through the Tuscarora along the entire summit of the ridge.

Dolly Sods to Mouth of Seneca, WV

Before we leave Dolly Sods, I want to describe another way to exit or gain access to Dolly Sods. The trip will leave Dolly Sods by turning left at the T-intersection and returning to the Jordan Run Road intersection. Another way to leave is to go straight ahead at the T-intersection, drop down to Red Creek Valley, continue through Laneville, and intersect with WV Rt. 32. If you turn right onto Rt 32, you will enter the southern end of Canaan Valley in a mile or two. If you want to access Dolly Sods from Canaan Valley, head south from the valley and take the Laneville Road to the T-intersection at Dolly Sods. For those of you who are backpackers and want a beautiful two-day hike, the Red Creek backpacking trail starts at the Forest Service building near the bridge crossing Red creek, loops up and through Dolly Sods, and returns to the service building.

Leave Dolly Sods and retrace your path back to Jordan Run Road and WV Rt. 28. At WV Rt 28, turn right and head south to Mouth of Seneca. Along the way, you will see some spectacular outcrops of both the Oriskany and Tuscarora sandstones.

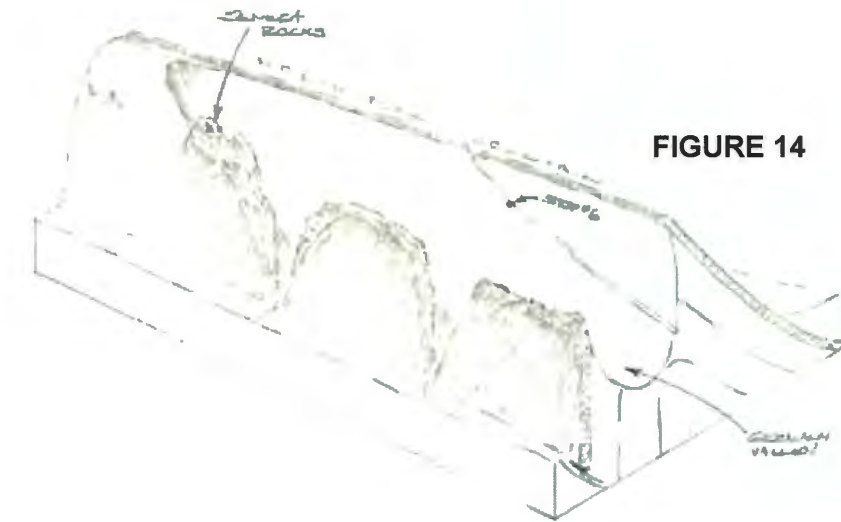


FIGURE 14

Stop #5: Mouth of Seneca, WV

Seneca Rocks, a well-known tourist spot, is the vertical outcrop of the Tuscarora sandstone exposed in the western limb of the Wills Mountain Anticline. Invariably, you will see rock climbers on the front face of the outcrop (Figure 14). During World War II, the Army used the rocks to train their commando troops in rock climbing.

Just beyond the intersection is a driveway leading to a Forest Service Information Center. If you feel ambitious, a climb to the top of Seneca Rocks is in order. A path to the top of the outcrop begins at the visitors center and ascends the front face of the outcrop. While the hike will take about an hour, it is worth the time. As you climb, take time to observe the Tuscarora sandstone. I think you can see why the Tuscarora is the major ridge-former in the Appalachian Mountains. There aren't many rocks more resistant to weathering and erosion than this one.

A second way to the top is by crossing North Fork and taking a road that leads through the water gap at the southern edge of Seneca Rocks (Stop #6). Once through the gap, a path takes off to the left and begins the climb to the top. The red rocks you will be climbing on belong to the Ordovician Juniata Formation which is the third and oldest of the three red beds that you will encounter during the trip. Once at the top, you'll be 900 feet (277 m) above the valley floor. Behind you will be the northernmost end of Germany Valley. You will get a better view of Germany Valley at a later stop on North Fork Mountain. In front of you will be the Allegheny Structural Front. Dolly Sods will be just barely within your line of sight along the Front to the north. The highest point in West Virginia, Spruce Knob at 4,863 feet (1,482 m) will be just out of sight along the Front to the south. As you look due west, you will see a small stream that has carved its channel back into the edge of the Front. On your return to Morgantown, you will follow this stream valley back up onto the Front. A note of caution. Be careful while you are on the summit of Seneca Rocks; too many lives have been lost by falling from the top.

Mouth of Seneca, WV to Seneca Caverns

Continue south on WV Rt. 33 toward Riverton. (If you are interested in going into a commercial limestone cavern, turn right at Riverton and follow the road to Seneca Caverns.) Along the way, you will pass sinkholes where the limestone has been dissolved along the intersections of two sets of joints (Figure 15). Caverns form as groundwater dissolves limestone along fractures and joints. The limestones in this case are

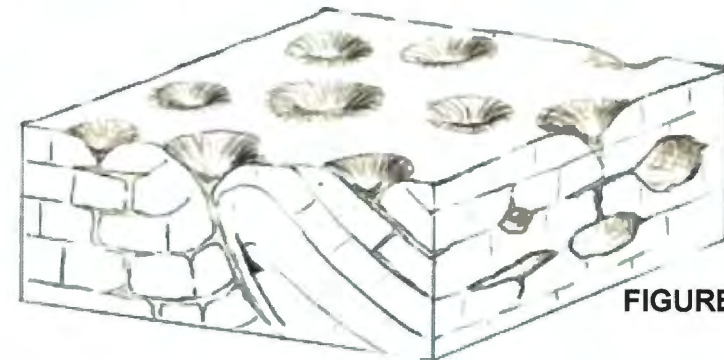
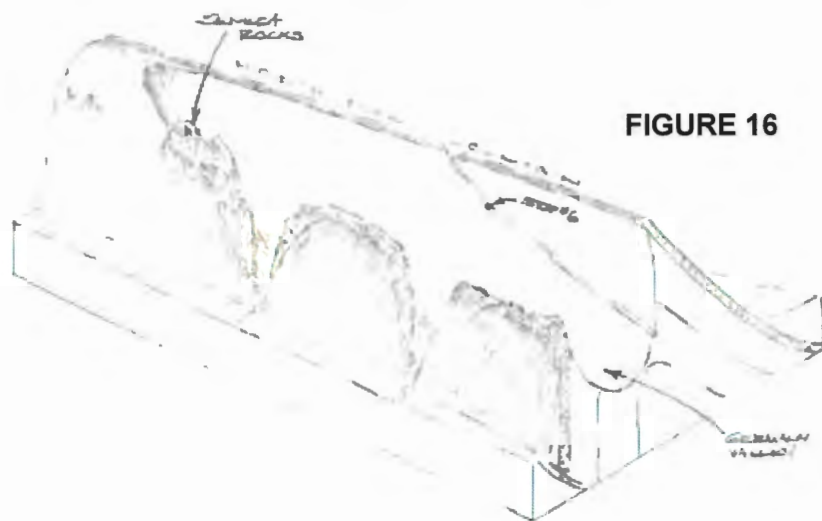


FIGURE 15

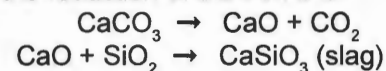
the Ordovician Black River and Stones River formations. Even if you don't choose to enter the caverns, along the way you will be able to see excellent examples of sinkholes that characterize karst topography that commonly forms in regions underlain by limestones.



Seneca Caverns to North Fork Mountain: Stop #7

Return to Riverton and continue south on WV Rt. 33, passing through Judy Gap and into Germany Valley. As you climb the western flank of North Fork Mountain, you will have a truly spectacular view of Germany Valley. Near the top of North Fork Mountain, there will be a pull-off to the left which will be Stop #7 (Figure 16). From this vantage point, Seneca Rocks can be seen to your right at the very head of the valley. To the south of Seneca Rocks, you can see similar, but not so spectacular, outcrops of the Tuscarora sandstone along the vertical western limb of the structure and their associated V-shaped water gaps. Looking northward along the strike of North Fork Mountain, you can see the eastward dipping outcrop of the Tuscarora sandstone along the crest of the ridge. Imagine that at a point in time, the Tuscarora sandstone along North Fork Mountain arched up and over what is now Germany Valley and connected with the vertical outcrop of the Tuscarora

sandstone along the western limb of the anticline. Once the combination of physical weathering, mass wasting and erosion breached the resistant Tuscarora sandstone south of North Fork Gap and exposed the soft sandstones and shales of the underlying Juniata Formation, Germany Valley began to form. Eventually erosion carved through the Juniata and Martinsburg formations, exposing the underlying Ordovician limestones that now form the valley floor. Greer Limestone's Germany Valley quarry can be seen toward the northern end of the valley. According to their estimates, at the present rate of production, Greer has enough high-quality limestone in the quarry to last for 500 years before they go underground. Obviously, Greer Limestone Corporation plans to be in business for a long time. Most of the limestone Greer produces from the Germany Valley quarry is used in blast furnaces to remove silica contaminants during the reduction of the iron ore:



It is also blended with the more magnesium-rich limestones from their operation at Greer to make agricultural lime.

If you're interested in fossils, you might investigate the outcrop of the Martinsburg Formation directly across the road from the overlook. The rocks are quite fossiliferous and you should have no trouble finding a variety of marine fossils. While most will be fossilized shells, if you're lucky, you may find a trilobite or two. A word of caution. Because the outcrop is located in a bend in the road, stay well away from the edge of the pavement and always have someone on the lookout to warn you of oncoming traffic.

While you are at this vantage point, I think it is interesting to point out that the sequence of rocks you see, from the Ordovician Black River and Stones River limestones that underlie the floor of Germany Valley to the Pennsylvanian Pottsville sandstone that outcrops along the Front, represents about 200 million years of Earth history. When the carbonate sediments that formed the Ordovician limestones rocks were being deposited, the first vertebrates were evolving in the form of jawless fish. By the time the Pottsville sediments were being deposited during Pennsylvanian time, animal evolution had advanced all the way through the amphibians to the first reptiles. While there was no life on land during Ordovician time, it began to appear during Devonian time and by the Pennsylvanian, the land was covered with forests. This was a time

when the vast swamps that accumulated the peat that would eventually be converted into our eastern coals covered the land. Amphibians dominated the swamps while early reptiles ventured onto the land. In addition, the Pennsylvanian Period has often been called the “Age of the Insect” when dragonflies with three-foot wingspans droned through the forests and swamps and foot-long cockroaches scurried about on the forest floor.

North Fork Mountain to Spruce Knob (Stop #8) to Mouth of Seneca, WV

Retrace the route back through Judy Gap and head north on WV Rt. 33. About a mile or so north of Judy Gap, the road to Spruce Knob turns off to the left. There isn't a lot to see at Spruce Knob. Although you will be on the edge of the Front, the view is not as spectacular as that from Dolly Sods. If you want to be able to say that you visited the highest point in West Virginia, by all means, go. It will take about an hour for the trip up and back. Otherwise, continue north on WV Rt. 33 to Mouth of Seneca.

Mouth of Seneca, WV to Harman, WV

At Mouth of Seneca, turn left and follow WV Rt. 33 toward Harman. For those who are backpackers, just west of Mouth of Seneca, a road to the left leads to the Seneca Creek Campground. A trail begins at the campground and ends up at Judy Springs Campground on Spruce Knob. The trail is a very easy hike and is quite scenic. While a round trip can be made in a long day, I would recommend making it a two-day trip with an overnight stay at Judy Springs Campground.

As you continue on WV Rt. 33 toward Harman, you will climb back up onto the High Plateau. However, because you followed a stream that had incised its channel back into the plateau, you will emerge onto the plateau several miles west of the Allegheny Structural Front. As you make the climb, see if you can identify the rock formations you pass. The red beds should give you an idea as to where you are stratigraphically as you make your way to the top. The western headwaters of these

eastward-flowing streams represents the Eastern Continental Divide. Streams that headwater east of the Divide, such as the Potomac River, flow to the Atlantic while those the headwater west of the divide flow to the Gulf of Mexico via the Ohio and Mississippi rivers.

Harman, WV to Canaan Valley

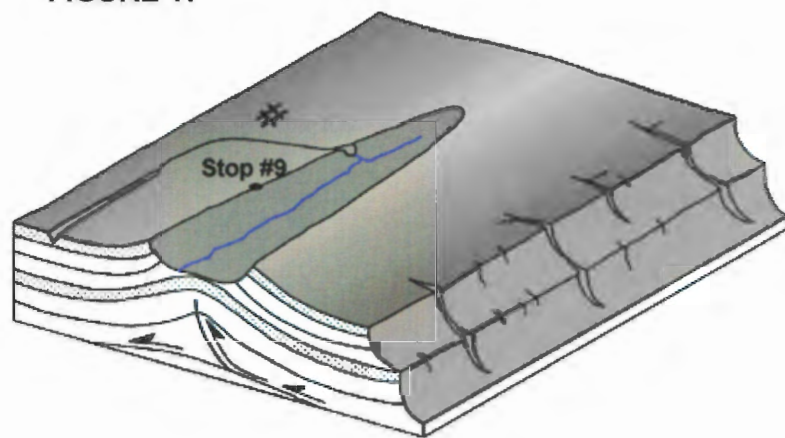
At Harman, turn right on WV Rt. 32. Just before you enter the southern end of Canaan Valley, you will pass the road leading to Laneville that I suggested was an alternative route to or from Dolly Sods. Immediately past the intersection, you will see the vertical outcrops of the Greenbrier limestone. Canaan Valley was formed by the breaching of the Blackwater Anticline. As you enter Canaan Valley, the entrance to Canaan Valley State Park is to the left and the entrance to Weiss Knob ski slopes is to the right. As you continue northward through the valley, you are driving parallel to the axis of the breached Blackwater Anticline. Canaan Mountain along the western side of the valley and Cabin Mountain along the eastern side are monoclinal ridges held up by outcrops of the Pottsville sandstone. Outcrops of the Greenbrier limestone that underlies the valley floor can be seen in the road cuts. The Pocono sandstone just barely comes to the surface along the axis of the structure. The Blackwater River headwaters in the southern portion of the valley and crosses the roadway at a small culvert. You will recognize it by the number of parked cars belonging to fishermen. I have NEVER come through the valley when there weren't fishermen in the stream. What has always amazed me is that the stream at that point is about four feet wide and two feet deep. Eventually, the river will leave the valley following a water gap through Canaan Mountain near the northern end of the valley.

Canaan Valley to Canaan Mountain: Stop #9

Toward the northern end of the valley, the roadway crosses the valley and begins to climb Canaan Mountain. The redbeds that appear along the roadway belong to the Mauch Chunk Formation. Just before you reach the top of the mountain, Stop #9 will be at a pull-off to the right.

You are again standing on the Pottsville sandstone looking across the valley to Cabin Mountain (Figure 17). Imagine the Pottsville sandstone arching over the valley and connecting with the Pottsville outcrop along Cabin Mountain. Your stop at Dolly sods is directly east of your present location beyond Cabin Mountain. The northern end of Canaan Valley

FIGURE 17



is an uninhabited swamp-marsh-bog complex. Botanist friends tell me that the plant community within the northern portion of the valley is very unique. Tundra and taiga plants growing there are leftovers from the periglacial climates that characterized the region during the maximum advance of the Pleistocene ice sheet which, for this region, was just south of the Pennsylvania-New York state lines. .

Directly across the road from the stop, the outcrop of the Pottsville sandstone may provide some excellent fossils of the types of plants that formed the coals for which West Virginia is famous. If you are interested in plant fossils, you might consider buying a publication available from the West Virginia Geologic and Economic Survey entitled "*Plant Fossils of West Virginia*" by Bill Gillespie, John Clendenning, and Herman Pfefferkorn. It's about as complete a treatment of Pennsylvanian fossil plants that you'll find anywhere. The fossils you will find at this site include a variety of leaves of the so-called "tree ferns" that were not true ferns but rather were seed bearers whose fronds resembled ferns. The

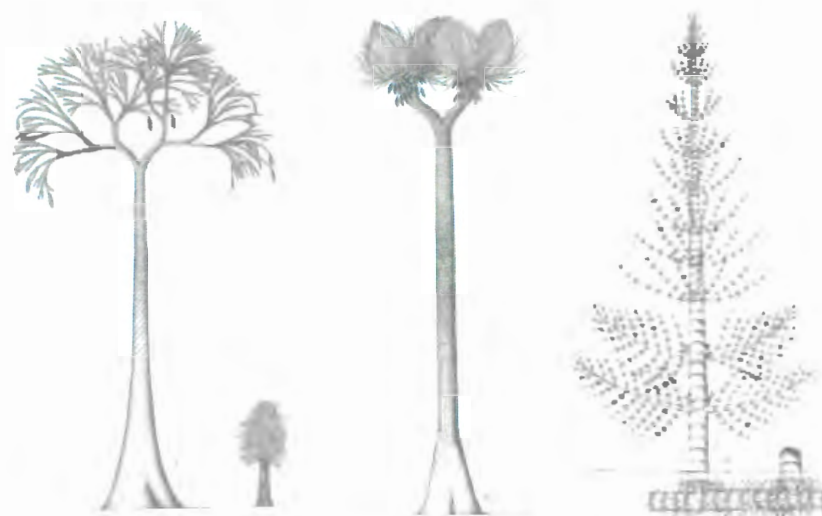


FIGURE 18

major plants growing during Pennsylvanian time include *Calamites* whose stem looks like bamboo, and *Lepidodendron*, and *Sigillarian* whose stem impressions look like the diamond pattern of a doormat (Figure 18, from "*Plant Fossils of West Virginia*"). The difference between the two fossils is that the diamond pattern spirals around the stem in lepidodendrons while it is aligned parallel to the stem in sigillaria. The stem of *Calamites* looks like the segmented stems of bamboo.

Canaan Mountain to Blackwater Falls State Park Stops #10 & #11.

Continue toward Davis, West Virginia. As the roadway descends from Canaan Mountain, the slope of the roadway follows the gentle slope of the west limb of the Blackwater Anticline. Note also the numerous blocks of Pottsville sandstone, the rugged topography, the sandy soil, and the dominance of conifers along the way. You will cross the Blackwater River just as you enter Davis. Just west of Davis, turn left onto the access road to Blackwater Falls State Park. Follow the road until it ends in the parking lot for the overlook located directly across the gorge from the lodge.

Stop #10

Stop #10 will be at the overlook (Figure 19). After leaving Canaan Valley, the Blackwater River flows westward to Davis where it turns southward, eventually flowing into the Cheat River. Along the way, the stream carved the gorge you see before you. At this point, you are standing on the Pottsville sandstone at the edge a youthful V-shaped stream valley that is 485 feet (148 m) deep. The gorge has often been referred to as the "Grand Canyon of the Blackwater". The dark color of the water is due to the tannic acid that is released by the decay of the leaves and bark of the hemlock trees that abound in the area. While the tannic acid does add an interesting flavor to the water, to my knowledge, the water isn't harmful to drink. During the early part of the last century, Davis and a nearby town, Thomas, were centers for the tanning of leather, primarily because of the local availability of tannic acid.

Stop #11

Backtrack along the access road to the parking lot serving the Falls. Blackwater Falls speaks for itself. Most individuals are unaware that waterfalls are very ephemeral features; geologically, they don't last very long. As you stand at the falls, note the shapes of the rocks at the base of the Falls. I think you can see where, based on their shapes,

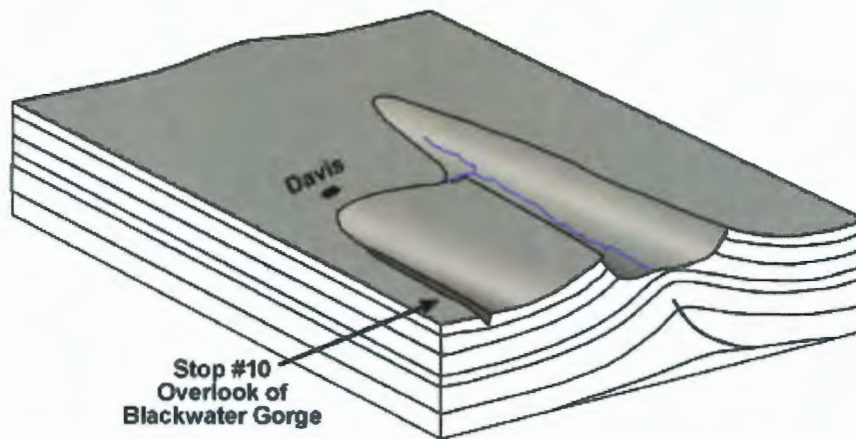


FIGURE 19

that the rocks came from the lip of the falls. Over time, as the softer underlying rocks are eroded, support for the outcrop of the sandstone that makes up the lip of the falls is removed. Lacking support, the sandstone along the lip of the falls breaks away, resulting in the slow retreat of the falls upstream upstream (Figure 20). As falls retreat and decrease in height, they eventually are turned into rapids which, in turn, are reduced to mere riffles in the stream. As you observe Blackwater Falls, keep in mind that they originated downstream where the Blackwater River flowed into Cheat River.

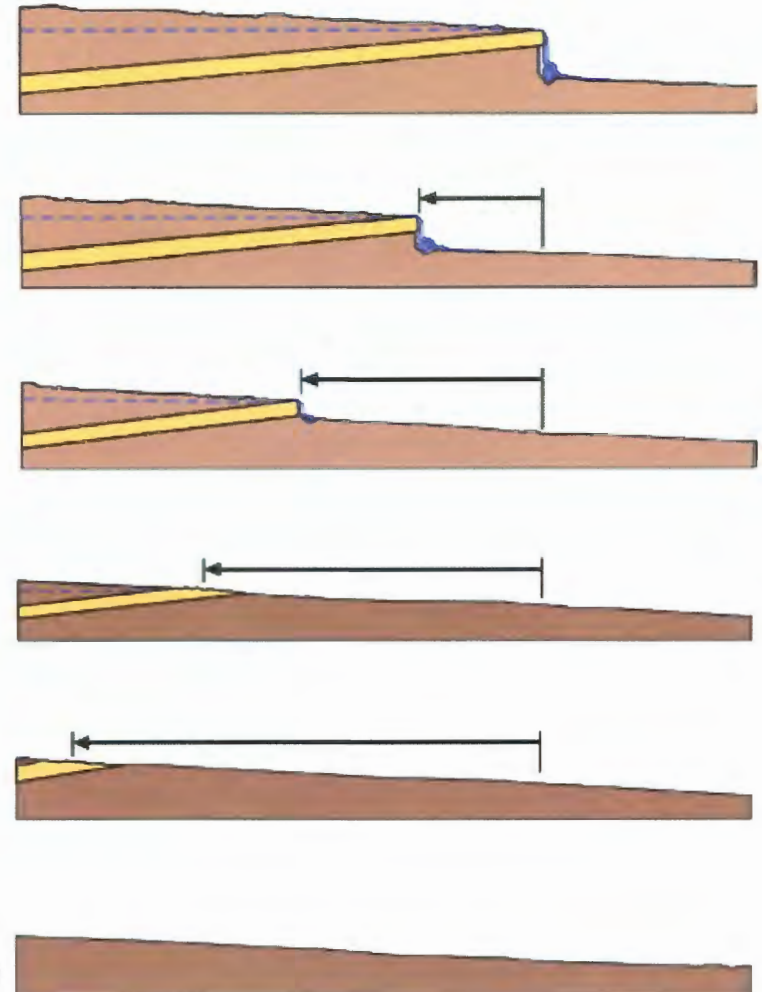


FIGURE 20

Blackwater Falls State Park to Backbone Mountain Stop #12

Leave Davis, West Virginia, and head west through Thomas, West Virginia. Take WV Rt. 219 out of Thomas through Fairfax Stone. Just west of Fairfax Stone, the roadway begins to descend Backbone Mountain. Part way down the mountain, turn off to the left at a scenic overlook. At this point, you are on the eastern limb of the breached Deer Park Anticline, the same structure you crossed at Oakland, Maryland (refer to Figure 10). From the overlook, your view is across rolling terrain underlain by the Chemung Formation. As you've seen before, this type of topography is expected where the underlying rocks are a mixture of sandstones and shales and where the bedding along the axis of the structure is relatively flat lying. The western limb of the breached structure can be seen along the western skyline.

Backbone Mountain to Morgantown, WV

Continue to Silver Lake. Turn left onto WV Rt. 24 which is a shortcut to U.S. Rt 50. Turn left on US Rt. 50. Follow US Rt. 50 through Fellowsville to WV Rt. 92 North. Follow WV Rt. 92 to Reedsville. At Reedsville, take WV Rt. 7 back to Morgantown. I sincerely hope that this trip has not only been enjoyable but has developed in you a better understanding and appreciation of the geologic processes that constantly shapes the land around us.

I-68/I-70: A WINDOW TO THE APPALACHIANS

by

Dr. John J. Renton
Dept. of Geology & Geography
West Virginia University
Morgantown, WV

Introduction

The Appalachian Mountains are probably the most studied mountains on Earth. Many of our modern ideas as to the origin of major mountain systems evolved from early investigations of the Appalachian region. The Appalachians offer a unique opportunity to experience the various components of an entire mountain system within a relatively short distance and period of time. Compared to the extensive areas occupied by other mountain systems such as the Rockies and the Alps, the Appalachians are relatively narrow and can be easily crossed within a few hours driving time. Following I-68 and I-70 between Morgantown, WV, and Frederick, Maryland, for example, one can visit all of the major structural components within the Appalachians within a distance of about 160 miles.

Before I continue, I would like to clarify references to the Allegheny and Appalachian mountains. The Allegheny Mountains were created about 250 million years ago when continents collided during the Alleghenian Orogeny to form the super-continent of Pangea (**Figure 1**). As the continents collided, a range of mountains were created in much the same fashion that the Himalaya Mountains are now being formed by the collision of India and Asia. About 50 million years after its



Figure 1

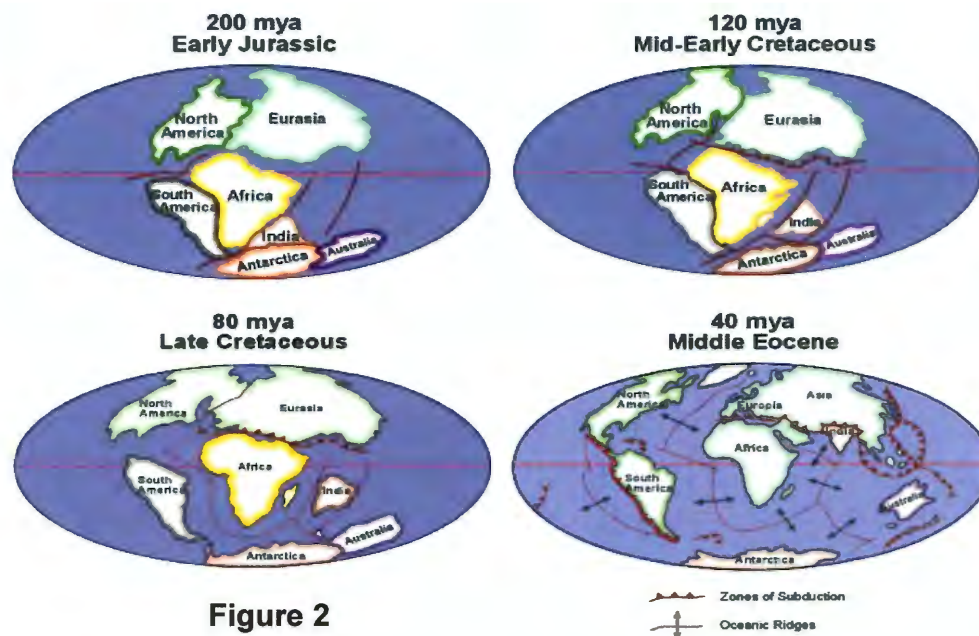
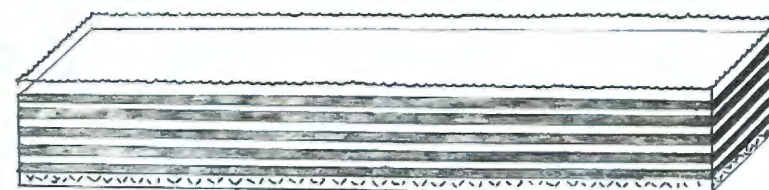


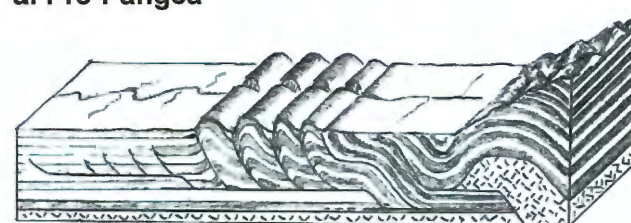
Figure 2

with some of the rocks exposed in Europe from northern Ireland through Scotland to Scandinavia. Over the next 100 million or so years, the combined efforts of weathering, mass wasting, and erosion wore the topography of the original Allegheny Mountains down to a flat, featureless plain nearly at sealevel. About 60 million years ago, the entire eastern portion of North America from the continental interior to the east coast was uplifted into a broad arch with the apex rising about 5,000 feet (1,525 m) above sea level. As the existing streams, rejuvenated by the uplift, began to carve their channels down to the newly formed baselevel, the present topography of the Appalachian region emerged. A schematic representation of the evolutionary history of the Appalachians is illustrated in **Figure 3**. It is important to keep in mind as you traverse the Appalachians along the route of I-68 and I-70 that the *structures* you see, the folds and faults, are very old, dating back to the Alleghenian Orogeny 250 million years ago, while the present *topography* of the region we now know as the Appalachian Mountains is the result of erosion that has taken place over the past 60 million years.

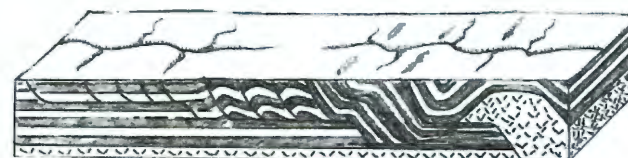
creation, Pangea began to break up with the break occurring parallel to the axis of the original mountains. As the pieces that were to become our present continents moved away from each other, the Indian, Atlantic, and Arctic oceans were created (**Figure 2**). As North America split away from Europe and North Africa, part of the mountain chain went with North America to eventually become our present Appalachians while the rest of the mountain chain remained with Africa and is now to be found in North Africa as the Atlas Mountains



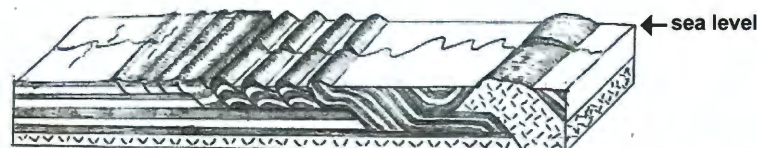
a. Pre-Pangea



b. 250 MYA - The Formation of Pangea



c. 100 MYA - After Formation of Pangea



d. After uplift and Erosion

Figure 3

Basic Geologic Information and Principles

In order to help you better understand what you will see along the route of the trip, I have included a review of some basic geologic topics.

Geologic Structures: The geologic structures are *folds*, *faults*, and *joints*. The dominant structures you will see during this field trip are folds. Based on their shape, folds are divided into *symmetric*, *asymmetric*, *overturned*, and *recumbent* (Figure 4).

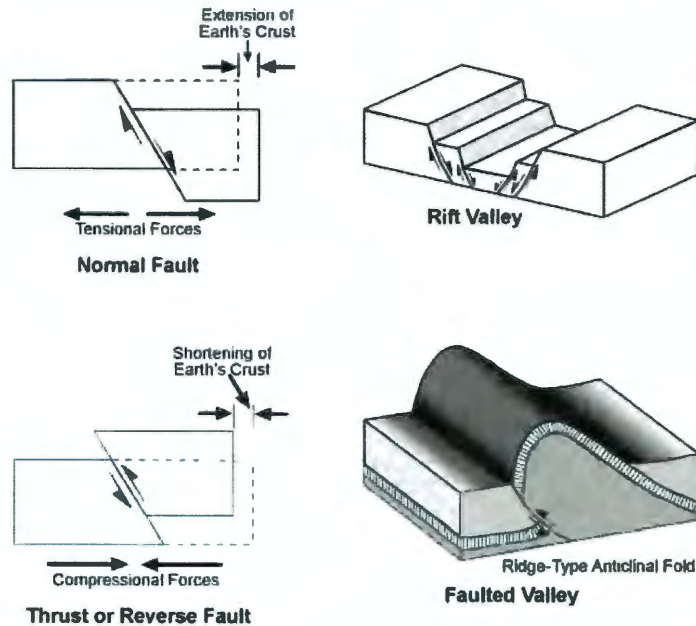
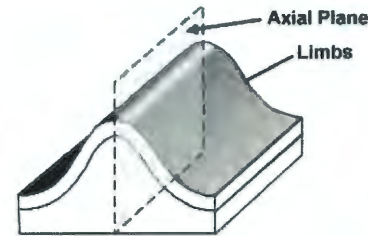


Figure 5.

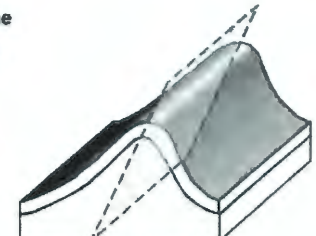


Axial Plane: Vertical
Limbs: Dip in opposite direction
at same angle



a. Symmetrical

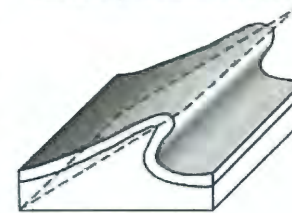
Axial Plane: Inclined
Limbs: Dip in opposite direction
at different angle



b. Asymmetrical

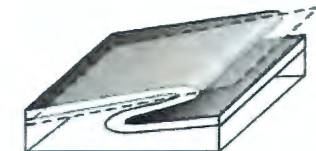
Figure 4.

Axial Plane: Inclined
Limbs: Dip in same direction



c. Overturned

Axial Plane: Approaches the
Horizontal



d. Recumbent

Three criteria are used to describe the shape of folds: 1) the attitude of the *limbs*, 2) the attitude of the *axial plane*, and 3) the angle, called the *dip*, that the limbs make with the horizontal. The axial plane is an imaginary plane drawn parallel to the long dimension of the fold that attempts to divide the cross section into equal halves. A symmetric fold has a vertical axial plane with limbs that dip away from each other at equal angles of dip (refer to Figure 2). The axial plane of an asymmetric fold is inclined with the limbs dipping away from each other, but at different angles of dip. Overturned folds are those whose limbs dip in the same direction. A recumbent fold is defined as one whose axial plane and limbs approach the horizontal. Except for the recumbent style, you will see examples of all of the fold types as the trip progresses.

The three major types of faults, *thrust* (or *reverse*), *normal*, and *strike-slip* are illustrated in Figure 5. Although faults are present throughout the Appalachians where their presence plays a major role in much of topography and structures you will see, their presence is not as evident at the surface as are the folds. Of the three types of faults, thrust faults dominate throughout the Appalachians, reflecting the compressional forces responsible for the formation of the mountains.

Joints are fractures in rocks along which there has been no appreciable movement. All rocks everywhere contain joints as will be evident in every rock outcrop exposed along the roadway.

Stratigraphy: Stratigraphy is the study of sedimentary rocks. A characteristic of all sedimentary rocks is that they are **bedded**. Initially, all sediments are laid down horizontally with the oldest layer being on the bottom with the overlying layers becoming progressively younger. Whether they now appear horizontal at the surface depends upon the kind of deformation they have been subjected to subsequent to their being converted into rock. If they are simply uplifted, the bedding of the rocks exposed at Earth's surface will still be horizontal. An excellent example are the rocks seen in the Grand Canyon that are the result of the vertical uplift of the Colorado Plateau over the past 20 million years. If, on the other hand, the rocks were subjected to compressive forces, as in the case of the Appalachians, the rocks will undergo folding.

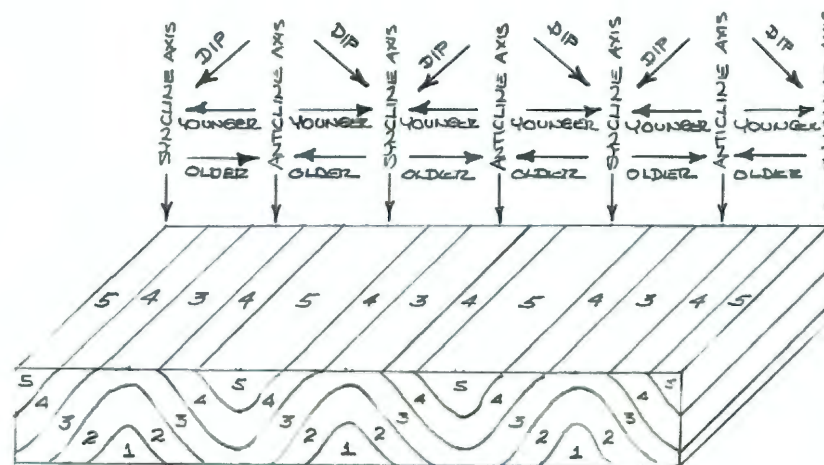
Whether flat-lying or folded, the sedimentary rocks found in any area are summarized in a **stratigraphic column** which shows the vertical sequence of the rocks and their relative ages. The stratigraphic column for this trip is found in **Figure 6**. One of the most difficult aspects of any geology field trip is to keep track of the various rock units you will be seeing. I would suggest that you keep Figure 6 conveniently available so that you can readily refer to it to identify the stratigraphic location of the rocks you will see.

Bedding Attitude: Throughout most of this trip, the sedimentary rocks were uplifted with compressional deformation that resulted in the beds being folded and faulted. In the area of Morgantown and to the west, in a region called the Appalachian Low Plateau. The structures underlying the Low Plateau are symmetrical folds with amplitudes so small that the rocks appear horizontal. A few miles east of Morgantown, you will leave the Low Plateau and enter The Appalachian High Plateau. While the structures underlying the High Plateau are mostly symmetrical folds, the amplitudes of the folds are high enough that the structures form ridges. As you drive eastward across the High Plateau, the fold amplitudes and the angle of the bedding observed in the outcrops along the roadway changes. In one exposure, the bedding may be horizontal while in others, it may dip toward you (to the west) or away from you (to the east) Get into the habit of paying attention to the attitude of the bedding of the rocks along the roadway. In areas of folded rocks, the bedding will be horizontal as you cross the axis of an anticline or a syncline. As you approach the

Figure 6: Stratigraphic Column

Pennsylvanian System	
	Dunkard Group
	Monongahela Formation
	Conemaugh Formation
	Allegheny Formation
	Pottsville Formation
Mississippian System	
	Mauch Chunk Formation
	Greenbrier Formation
	Pocono Group
	Purslane sandstone
	Rockwell Formation
Devonian System	
	Hampshire Formation
	Chemung Formation
	Foreknobs Formation
	Brallier Formation
	Hamilton Group
	Mahatango Formation
	Harrell/Marcellus shale
	Needmore shale
	Oriskany sandstone
	Helderberg Formation
	Keyser formation
Silurian System	
	Tonoloway limestone
	Wills Creek Formation
	Bloomsburg Formation
	McKenzie Formation
	Clinton Group
	Rochester shale
	Keefer sandstone
	Rose Hill Formation
	Tuscarora sandstone
Ordovician System	
	Juniata Formation
	Martinsburg Formation
	Chambersburg Formation
	Chambersburg limestone
	New Market limestone
	Row Park limestone
	Beekmantown Group
	Pinesburg Station dolomite
	Rockdale Run Formation
	Stonehenge limestone
Cambrian System	
	Conococheague limestone
	Elbrook limestone
	Waynesboro Formation
	Weverton Formation
pre-Cambrian System	
	Catoctin Formation

axis of an anticline, the bedding will dip *toward* you (Figure 7). Because all of the folds in the Appalachians trend NE-SW, this will be to the west. Note also that as you approach the axis of an anticline, the rocks become progressively *older*, that is you are going *down* stratigraphically. In any area of folded rocks, the oldest rocks will be exposed in the axis of a breached anticline or in the center of a water gap cutting through an anticlinal fold. Conversely, as you drive toward the axis of a syncline, the bedding will dip *away* from you (in this case to the east) and the rocks will become progressively younger; you will be going *up* stratigraphically. In an area of folded rocks, the youngest rocks will be found in the axial region of a syncline which, most often, will be a valley floor. Monitoring the attitude of the bedding as you drive is the best way for you to keep track of the folds that you will be crossing.



LEGEND

5	YOUNGEST
4	
3	
2	
1	OLDEST

Figure 7.

Physiographic Provinces

Continents are subdivided into *physiographic provinces*. A physiographic province is defined as a region of which all parts are similar in geologic structure and climate and which has had a unified geomorphic history; a region whose pattern of landforms differ significantly from that of adjacent regions. The Appalachian region is divided into four physiographic provinces, which are from west to east: the *Appalachian Plateaus*, the *Valley and Ridge*, the *Blue Ridge*, and the *Piedmont* (Figure 8). While the trip will terminate in the Piedmont, many geologists do not consider the Piedmont Province as being part of the Appalachians.

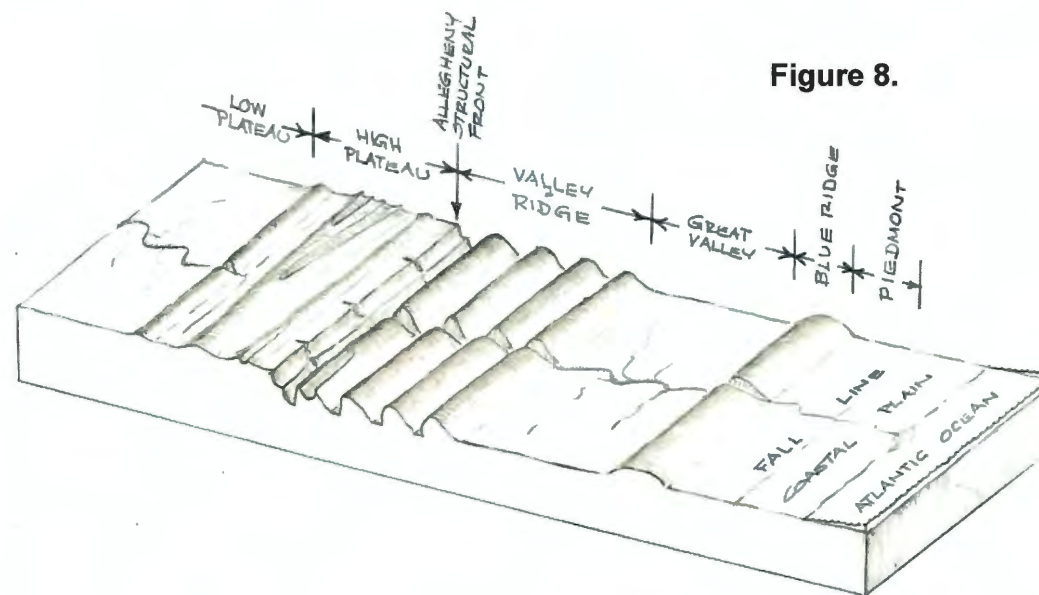


Figure 8.

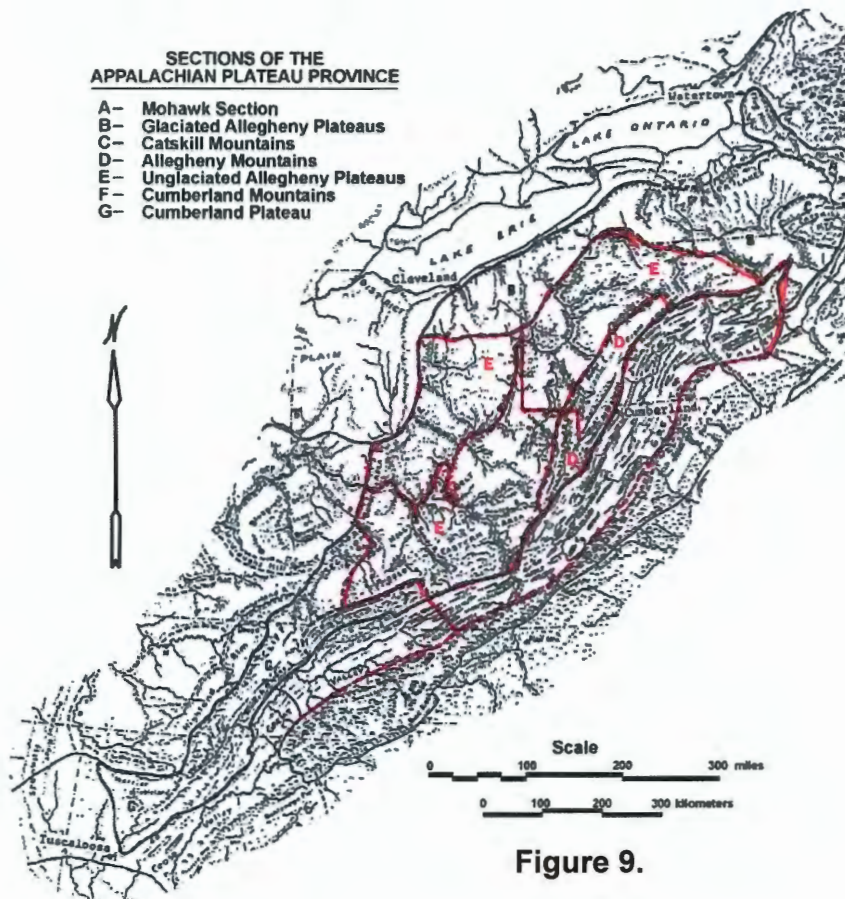


Figure 9.

because the dips on the limbs are so low (generally less than 2° or 3°) that the human eye cannot discern any dip on the beds.

Although faults are probably present in the area, they are of very low displacement and are rarely seen at the surface.

Typical of areas underlain by essentially horizontal rocks, the dominant stream pattern throughout the Low Plateau is dendritic (Figure 10). In general, the streams have progressed to the mature stage of geomorphic development with most of the major streams having developed floodplains and meanders. Other characteristics of a mature

As the name implies, there are several Appalachian plateaus (Figure 9). The most northerly plateau, the Mohawk Plateau, extends northward from the Mohawk and Hudson rivers into New England. Next, the Glaciated Allegheny Plateau extends from the Mohawk Plateau southward to the maximum extent of the Pleistocene ice advance just south of the New York-Pennsylvanian border. The largest plateau, the Unglaciated Plateau, extending southward to Kentucky, is divided into an eastern Allegheny Mountain Section or High Plateau, a western Low Plateau, and the southernmost Cumberland Plateau. The terms, High and Low Plateau are my own means to designate the two basic regions within the Unglaciated Plateau.

The Valley and Ridge Province is subdivided into the eastern Great Valley Section and the western Appalachian Mountain Section.

Appalachian Low Plateau: The Appalachian Low Plateau is the westernmost of the Appalachian Plateaus Physiographic provinces. The Low Plateau is largely underlain by rocks of Pennsylvanian age (refer to stratigraphic column in Figure 6). Morgantown is located near the eastern edge of the Low Plateau. As previously mentioned, the rocks exposed in road cuts from Morgantown are deformed into very low amplitude symmetrical folds that appear as though they are perfectly horizontal. The reason why the bedding appears to be horizontal is

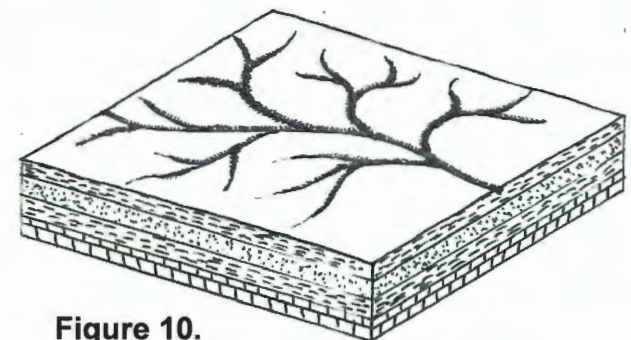


Figure 10.

topography include average distances from hilltops to valley floors, the *relief*, of a few hundred feet, with adjacent streams separated by rounded hills with relatively shallow slopes. The topography in the vicinity of Morgantown is typical of the province.

Most geologists consider the western limit for the Low Plateau to be located in central Ohio where glacial deposits and older Paleozoic rocks crop out. The easternmost limit of the Low Plateau and the beginning of the High Plateau is located just east of Morgantown at the western base of Chestnut Ridge. Chestnut Ridge is a dominant topographic feature that extends from just north of Uniontown, Pennsylvania, southwestward to Weston, West Virginia. The structure responsible for the ridge, Chestnut Ridge Anticline, is a symmetrical anticline. The NE-SW trend of Chestnut Ridge, and of all of the other major Appalachian structures, is the result of the great pressures that were applied from the southeast when the Allegheny Mountains were created about 250 million years ago. One can compare and contrast the topography of

the high and low plateaus by referring to the Morgantown 7.5' topographic map available from the West Virginia Geologic and Economic Survey.

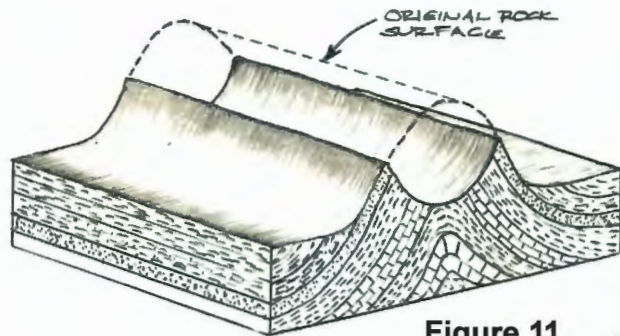


Figure 11.

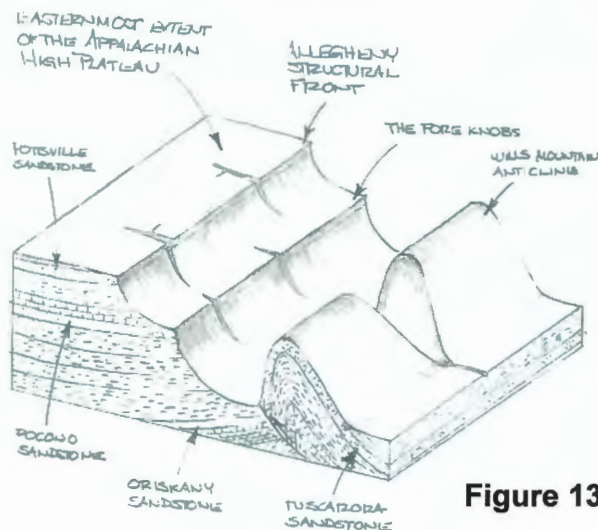


Figure 13.

The Alleghenian Mountain Section or Appalachian High Plateau: The Allegheny Mountain Section of the Unglaciaded Plateau, or Appalachian High Plateau, extends from Chestnut Ridge on the west to the Allegheny Structural Front on the east (refer to Figure 8). Rocks within the province range in age from Pennsylvanian to Devonian with the oldest rocks being exposed in the axial regions of breached anticlines (Figure 11). The dominant structures within the High Plateau are relatively high amplitude symmetrical folds with the increased amplitudes of the folds being due to the presence of thrust faults within the anticlinal cores that provided a vertical displacement of the rocks within the fold (Figure 12). The effect of the increased fold amplitudes is an increase in regional relief that results in a more rugged terrain than that seen throughout the Low Plateau to the west. Because of the increased relief of the High Plateau over that of the Low Plateau to the west, the Appalachian High Plateau has also been referred to as the Allegheny Mountains or the *open-fold* section of the Appalachian Plateaus. From central Pennsylvania to central West Virginia, the eastern-most edge of the Appalachian High Plateau is called the Allegheny Structural Front (Figure 13).

It is important to note that the highest elevations in the Appalachians are found just west of the Allegheny Structural Front and not, as one might expect, in

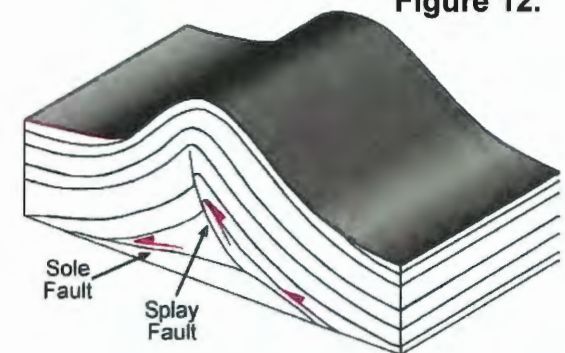


Figure 12.

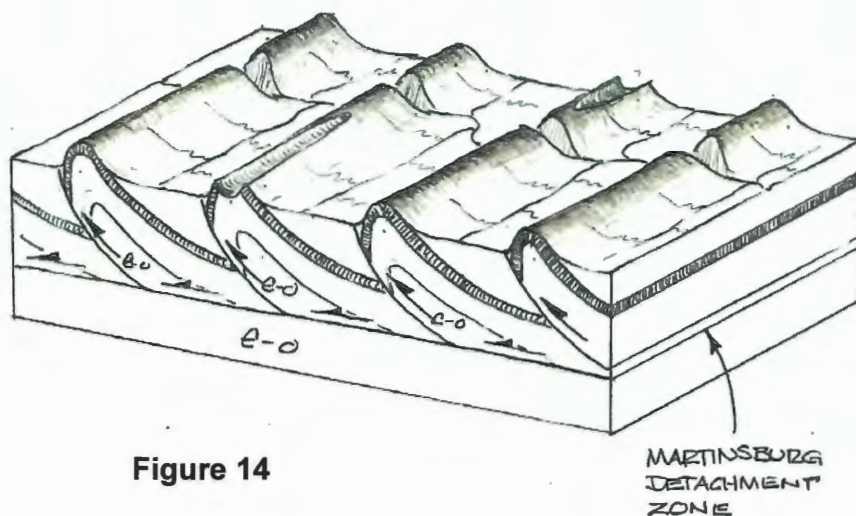


Figure 14

name reflects the dominance of northeast-southwest-trending parallel valleys and ridges within the province. For the most part, the ridges are high amplitude asymmetric to overturned folds, commonly broken on the western limb by high-angle thrust faults (Figure 14). The oversteepening of the folds to the west indicates an east to west direction of rock transport during the original mountain building episode. The wavelength of the folds in the Valley and Ridge (the distance between fold axes) is significantly less than the wavelength of the more open folds in the High Plateau to the west. Many of the anticlinal structures have been breached by erosion, exposing the oldest rocks of the region, the Ordovician, within anticlinal valleys. An excellent example of a valley that formed as the result of the breaching of an anticline that you may be familiar with is Germany Valley located in Pendleton County, West Virginia (Figure 15).

There are occasional synclinal ridges that you will observe along your route, the most well known being

the Appalachian Mountains to the east. The reason for this rather anomalous situation is due to the fact that the apex of the broad arch that was uplifted about 60 million years ago from the Mississippi River Valley to the Atlantic Ocean is located along the eastern edge of the Appalachian Plateaus.

An important economic aspect of the Appalachian Plateau are the mineable coal deposits that are located within its boundaries with the coal beds being contained within the Pennsylvanian rocks. One particular coal bed, the Pittsburgh coal, often referred to as the most valuable rock layer in the world, accounts for 25% of all the coal mined in West Virginia.

Appalachian Mountain Section: The Appalachian Mountain Section of the Valley and Ridge Physiographic Province extends from the Allegheny Structural Front to the Great Valley and constitutes what is commonly referred to as the Appalachian Mountains. The

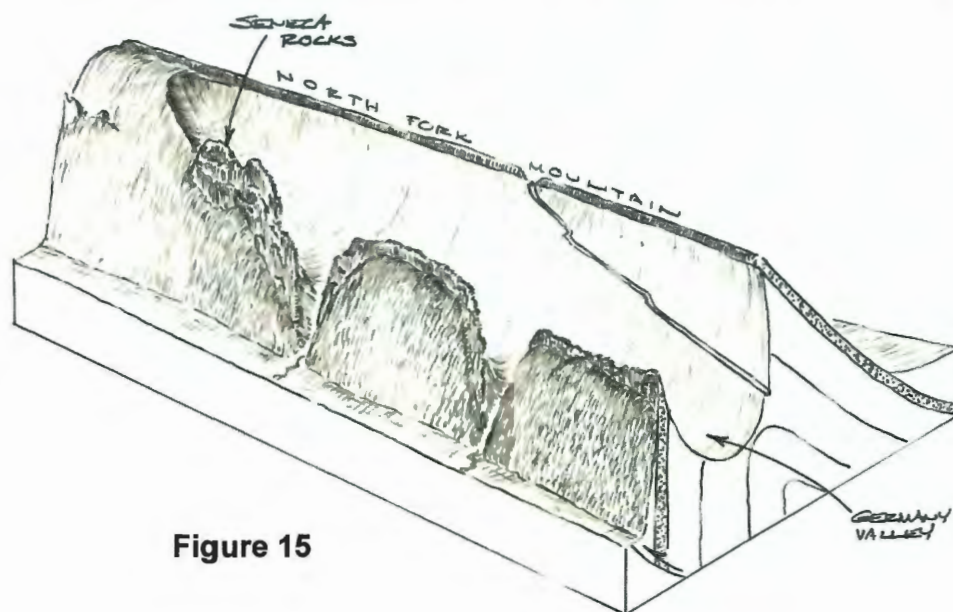
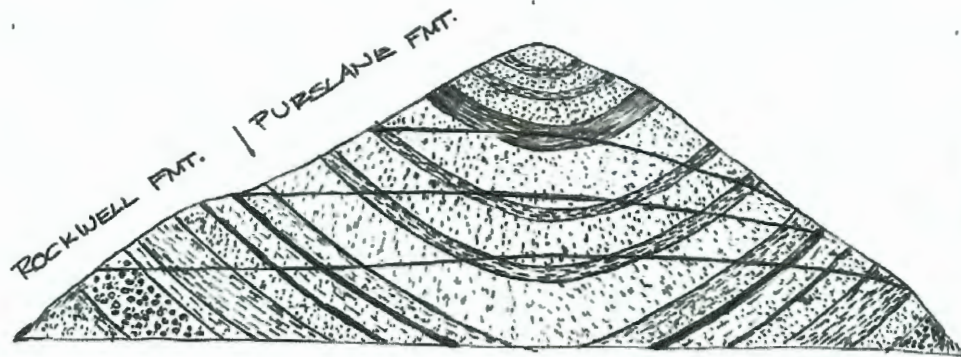
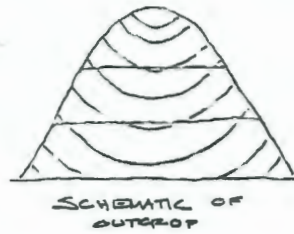


Figure 15



Figure 16a



LEGEND

	CONGLOMERATE
	SANDSTONE
	SILTSTONE
	SHALE
	COAL & BLACK SHALE

Figure 16b

Sideling Hill, Maryland. Synclinal ridges are formed as adjacent anticlines are breached with the subsequently valleys eventually being eroded below the elevation of the adjacent synclinal valleys, creating what geologists call "inverted topography" (Figure 16a and 16b). Eventually, the resistant rock layer becomes a tough caprock that remains high above the surrounding terrain as the rocks within the adjacent anticlinal structures are removed.

It is important to emphasize that the summits of all of the ridges within the Appalachian Mountains are lower in elevation than that of the easternmost edge of the Appalachian Plateau with the elevations of each more easterly ridge being generally lower than that to the west. This relationship results in the rather unique situation of one going down into the Appalachian Mountains when approached from the west.

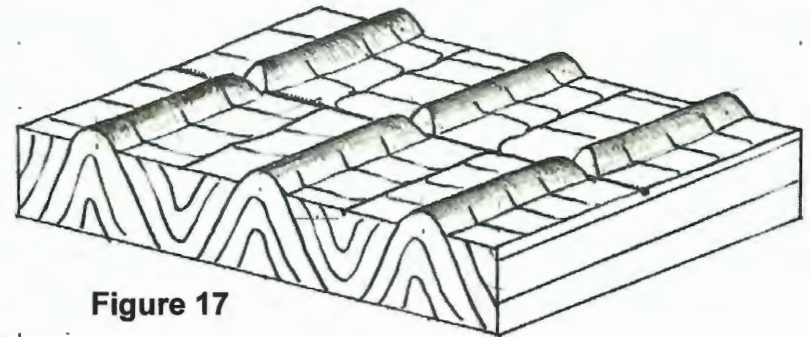


Figure 17

Because of the dominant northeast-southwest trending ridges and valleys, the stream pattern within the Valley and Ridge is *trellis* with the major streams cutting across the structures and tributaries draining the valleys (Figure 17). There is evidence that many, if not most, of the water gaps that cut across anticlinal structures follow vertical fault zones with the streams taking advantage of the zone of weakness.

The Great Valley Section: The Great Valley Section of the Valley and Ridge Province, commonly referred to as the Shenandoah Valley, extends eastward from the easternmost ridge of the Appalachian Mountain Section of the Valley and Ridge to the base of the Blue Ridge Mountains. Rocks within the valley are nearly all Cambrian and Ordovician limestones. Because of the water soluble nature of calcium carbonate, the rocks have been dissolved down to the mean level of the streams, resulting in a broad, flat valley. The few low ridges observed within the valley are in large part due to the occasional non-carbonate rock layer that is a bit more resistant to erosion. Although natural exposures of limestones are limited because of their solubility, numerous limestone rock outcrops can be seen in the fields. Typical of regions underlain by limestones, the soils are thin and are composed almost entirely of the insoluble materials, clay minerals and quartz, that were originally contained within the limestones. Also typical of areas underlain by limestones, the Great Valley shows extensive development of *karst topography* readily identified by the extensive number of sinkholes throughout the region (Figure 18). Because of their alkaline character, the soils are ideal for the growth of calcium-loving grasses which explains the widespread use of the land for the grazing of cattle. The red to orange color of the soil is typical of areas underlain

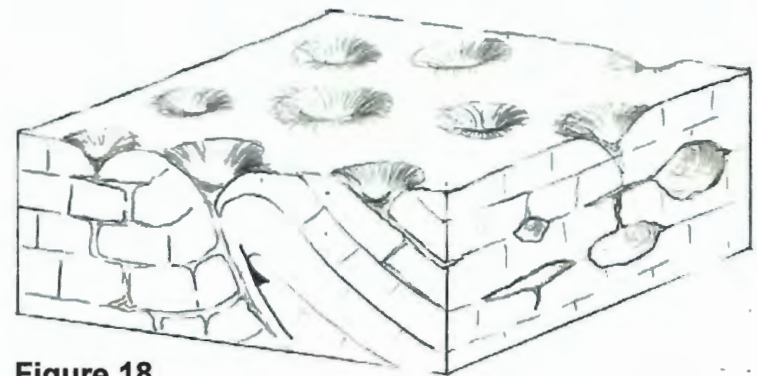


Figure 18

Table 1						
ORIENTATION	WEST			EAST		
FORCES	PASSIVE COMPRESSION ⇒			⇐ ACTIVE COMPRESSION		
ENERGY AVAILABILITY	MINIMAL			MAXIMUM		
GEOGRAPHIC REGION	APPALACHIAN PLATEAU		VALLEY & RIDGE PROVINCE		BLUE RIDGE MOUNTAINS	PIEDMONT
	LOW PLATEAU	HIGH PLATEAU	APPALACHIAN MOUNTAINS	GREAT VALLEY		
FOLD GEOMETRY	LOW AMPLITUDE SYMMETRICAL 	MEDIUM AMPLITUDE SYMMETRICAL 	HIGH AMPLITUDE ASSYMETRICAL 	HIGH AMPLITUDE ASSYMETRICAL 	RECUMBENT 	HIGHLY DEFORMED PLASTIC FLOW
FAULTS (REVERSE) 	MAY BE PRESENT WITH VERY SMALL DISPLACEMENTS	DISPLACEMENTS: 1's to 10's OF FEET	DISPLACEMENTS: 10's to 100's OF FEET	DISPLACEMENTS: 100's to 1000's OF FEET	DISPLACEMENTS: 1000's OF FEET TO MILES	DISPLACEMENTS: ESTIMATED INTO 10's OF MILES
METAMORPHIC FACIES				LOW GRADE	MEDIUM GRADE	HIGH GRADE
IGNEOUS ACTIVITY					MAFIC TABULAR INTRUSIONS	FELSIC PLUTONS
	1	2	3	4	5	6

by limestone and is due to the fact that the insoluble materials released by the dissolution of the limestones are coated by combinations of red iron oxides, Fe_2O_3 , and yellow iron oxyhydroxides, $\text{FeO}(\text{OH})$.

Structurally, the valley is underlain by many northeast-southwest trending high-displacement thrust faults and highly deformed asymmetric and overturned folds which, because of the limited exposures, are not always easy to observe. As one approaches the easternmost portion of the valley, the rocks show evidence of low-level metamorphism, the result of being located closer to the original zone of deformation (Table 1).

The carbonate rocks in the Great Valley are often so pure that they were both quarried and deep-mined. Uses of the limestone products range from the flux-stone used in the iron and steel industry to remove silicate contaminants from blast furnaces, for the manufacture of cement, and to coat the walls of deep coal mines in order to reduce the amount of flammable coal dust in the atmosphere of the mine. Throughout much of the northern Appalachian coal basin, it is used to treat and inhibit the production of acid drainage.

The Blue Ridge Physiographic Province: The Blue Ridge Physiographic Province makes up the Blue Ridge Mountains. Structurally complex, the Blue Ridge consists of highly deformed and metamorphosed pre-Cambrian and Cambrian rocks that have been intruded by basaltic and rhyolitic magmas. The province is actually an eroded *anticlinorium*, the South Mountain Anticlinorium. An anticlinorium is a broad regional anticlinal structure composed of lesser folds. In the area of the trip, the province extends from South Mountain on the west to Catoctin Mountain on the east with Middletown Valley located in between. Middletown Valley is floored by metabasalts and represents the core of the anticlinorium. To the south, erosion within the valley has exposed the billion-year old basement gneisses that underlie the structure. The basement rocks are of similar radiometric age beneath all of eastern North America! From central Ohio east to the Atlantic, the basement rocks are known as the Grenville Complex.

The Piedmont Physiographic Province: By definition, a piedmont is the plane or slope that exists at the base of a mountain. In this case, it is the sloping surface that extends eastward from the base of the Blue Ridge Mountains and disappears under the recent sediments of the Coastal Plain. The Piedmont Physiographic Province contains the most highly deformed rocks of the Appalachian region. Because of their highly deformed character, the rocks within the Piedmont succumb quite readily to chemical weathering. As a result, weathering over the past 100 million years has generated a thick *regolith* or *saprolite* that cover the rocks almost everywhere within the province. Below the thick layer of weathered material are amphibolites, schists, and ultramafic rocks known collectively as the Baltimore Complex. These rocks are interpreted to be oceanic crustal rocks that were shoved over the underlying younger rocks during a continent-continent collision that occurred 500 million years ago.

To the east, the Piedmont disappears under the Coastal Plain. The contact between the Piedmont and the Coastal Plain is referred to as the “Fall Line” because of the small waterfalls that commonly occur where streams flow from the more resistant rocks of the Piedmont onto the more easily eroded recent sediments of the Coastal Plain (refer to Figure 19). One of the best locations to view the Fall Line is at Great Falls Park just northwest of Washington, D.C. Here, the Potomac River has created a window to the Piedmont rocks which are otherwise covered by either saprolite or coastal plain sediments. Because bedrock within most of the Piedmont is rarely exposed, our trip will end at Frederick, Maryland, on the westernmost edge of the Piedmont.

The Coastal Plain Physiographic Province: Though not part of Appalachia, it is important to realize that the less consolidated materials of the coastal plain are, in reality, all the materials stripped from the Appalachians by erosion, brought east by rivers, and deposited along the eastern edge of the North American as part of its seaward extension, the continental shelf.

The Origin and Structure of the Appalachians

In order to get the most out of any field trip, it is essential to have a basic picture of the combined structure, stratigraphy, and erosional history of the area. Understanding how the structures within the area formed, although not essential, will add significantly to your overall understanding of the geology. In order to provide you with such an understanding, I must go beyond what you would learn in an introductory geology course. In the case of the Appalachians, it requires introducing you to a concept that describes the fate of sedimentary rocks that are involved in a major mountain building episode. The fact that you chose to go on this trip indicates that you are interested in understanding the geology of the Appalachians and would probably appreciate a more in-depth understanding of what you will see.

To illustrate how the structures formed, I have prepared two figures, **Figure 19** which is a block diagram depicting the present topography along with the various physiographic provinces and the subsurface structures and **Figure 20** (next page) that consists of five drawings that sequentially illustrate the evolution of the Appalachian structures.

The great mountains of the world were created by the collision of continents. A modern example, the Himalaya, are the result of the collision of India and Asia beginning about 45 million years ago, a collision that is not yet over as indicated by the frequency of earthquakes throughout the region combined with the fact that the Himalaya are still rising. The Himalaya, and all of the great mountains of the world including the Appalachians, are examples of *foldbelt mountains*, the name referring to the fact that a major portion of the mountain range

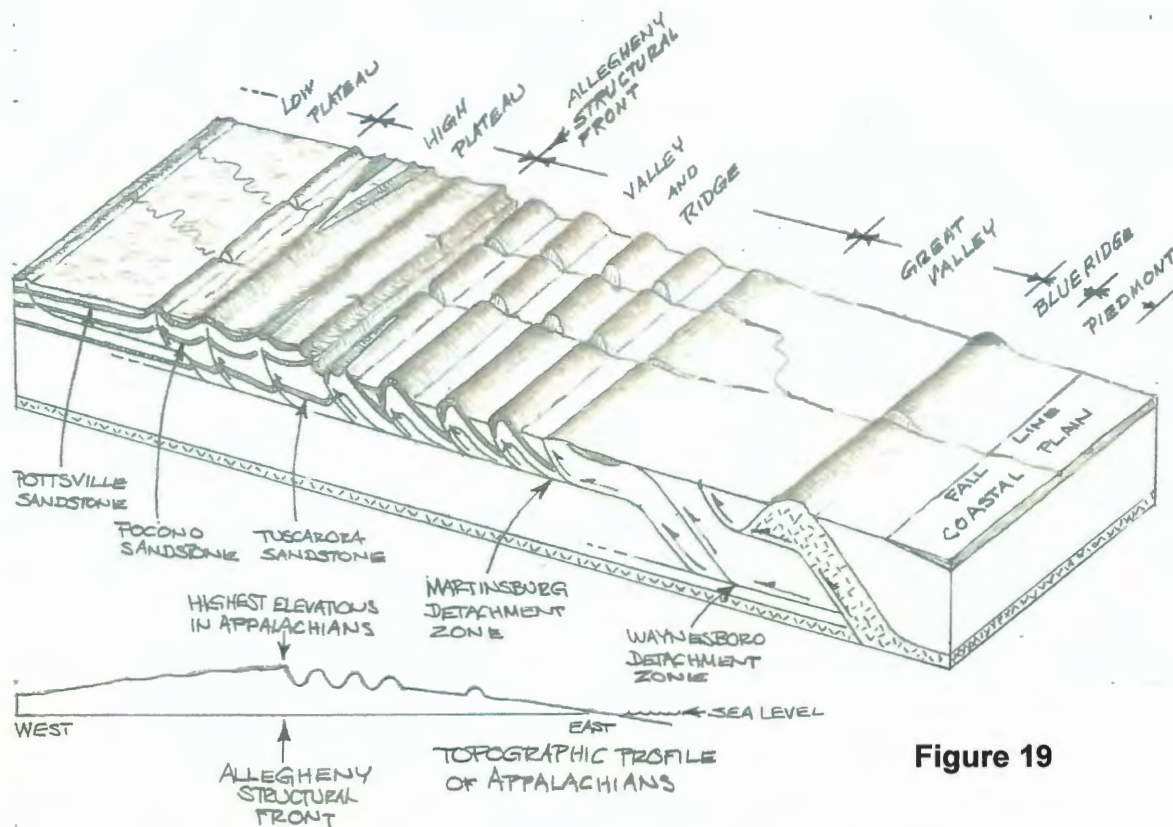


Figure 19